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PEDOLOGIC SOIL SERIES – RESILIENT MODULI RELATIONS

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By

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The pedologic soil series is the basic mapping unit utilized by the U.S. Department of Agriculture Soil Conservation Service (SCS). Modern soil survey reports are available for many counties throughout the United States. Numerous studies have indicated that soil series is an appropriate procedure for characterizing the engineering properties of surficial soils. For example, the Illinois DOT Soil Manual is keyed to pedologic soil series. The U.S. Army Corps of Engineers CERL group has cooperated with the USDA SCS in developing versatile software programming to access the SCS SOI-5 and SOI-6 data bases which include detailed information on more than 16,000 soil series mapped in the U.S.A. The purpose of this project was to determine the feasibility of using pedologic soil series for estimating the resilient modulus (E_{Ri}) of fine-grained subgrade soils. Most large-scale construction projects cut across many different soil series and it would be helpful to have a quick and economical method for estimating subgrade moduli for pavement design or other horizontal construction related purposes.   (continued on back)

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number 51. Professors E.J. Barenberg and M.R. Thompson were
the project investigators. This reproduction is provided for other
researchers, particularly those researchers in Army Laboratories
interested in the work.

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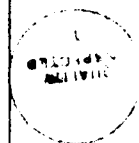
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INTRODUCTION

The development of horizontal facilities (highways, airfields, parking areas, etc) involves the consideration of large areas. Detailed soil explorations are normally not conducted to support the selection of subgrade soil inputs for pavement design.

The resilient behavior of a soil is an important property for pavement analysis and design. A commonly used measure of resilient response is the "resilient modulus", defined by:

$$E_R = \sigma_D/\varepsilon_r$$

where:

E_R: resilient modulus;

σ_D: repeated deviator stress;

ε_r: recoverable axial strain.

Repeated unconfined compression or triaxial testing procedures are often used to evaluate the resilient moduli of fine-grained soils and granular materials. Resilient moduli are stress dependent: fine-grained soils experience resilient modulus decreases with increasing stress, while granular materials stiffen with increasing stress level.

Thompson and Robnett (1) proposed an arithmetic model for describing the stress softening behavior of fine-grained soils. The model is shown in Figures 1 and 2. Extensive resilient laboratory testing, nondestructive pavement testing, and pavement analysis and design studies at the University of Illinois have indicated that the arithmetic model (Figure 2) is adequate for flexible pavement analysis and design activities.

In the arithmetic model, the value of the resilient modulus at the break-point in the bilinear curve, E_{Ri} (Figure 2), is a good indicator of a

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soil's resilient behavior. The slope values, K_1 and K_2, display less variability and influence pavement structural response to a smaller degree than E_{Ri}. Thompson and Robnett (1) developed simplified procedures for estimating the resilient behavior of fine-grained soils based on soil classification, soil properties, and moisture content.

The pedologic soil series is the basic mapping unit utilized by the U.S. Department of Agriculture Soil Conservation Service (SCS). A soil series is also assigned a "number". For example "Flanagan" is soil series #154. Modern soil survey reports are available for many counties throughout the United States.

Numerous studies have indicated that soil series is an appropriate procedure for characterizing the engineering properties of surficial soils. For example, the Illinois DOT Soils Manual (2) is keyed to pedologic soil series. The U.S. Army Corps of Engineers CERL group (3) has cooperated with the USDA SCS in developing versatile software programming to access the SCS SOI-5 and SOI-6 data bases which include information on more than 16,000 soil series mapped in the U.S.A. It is easy to gain quick access to an extensive data base for any soil series.

The purpose of this project is to determine the feasibility of using pedologic soil series for estimating the resilient modulus (E_{Ri}) of fine-grained subgrade soils. Most large-scale construction projects cut across many different soil series and it would be helpful to have a quick and economical method for estimating subgrade moduli for pavement design or other horizontal construction related purposes.

The goal of this research is to establish a relation between soil series and subgrade modulus. If there is a strong relation, then the subgrade modulus values for design purposes could be obtained from readily available county soil reports and maps. Even if it is not possible to assign values

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for subgrade modulus based on soil series information, it may be feasible to determine which areas warrant more intensive field testing. Identifying problem areas would allow for more efficient and cost effective field testing.

PROCEDURE

Thompson (4) has summarized University of Illinois procedures for predicting subgrade E_{Ri} based on 9-kip Falling Weight Deflectometer (FWD) pavement surface deflection data. The subgrade E_{Ri} algorithms (based on ILLI-PAVE generated data bases) for flexible pavements are:

Surface Treatment and Granular Base

$$E_{Ri} = 24.2 - 5.71 \ D3 + 0.35 \ D3^2 \qquad (1)$$

Asphalt Concrete Surface > 3 inches and Granular Base

$$E_{Ri} = 25.0 - 5.25 \ D3 + 0.29 \ D3^2 \qquad (2)$$

Asphalt Concrete Surface and Granular Base

$$E_{Ri} = 24.1 - 5.08 \ D3 + 0.28 \ D3^2 \qquad (3)$$

Full-Depth Asphalt Concrete

$$E_{Ri} = 24.7 - 5.41 \ D3 + 0.31 \ D3^2 \qquad (4)$$

where:

E_{Ri} - Subgrade resilient modulus, (ksi)

D3 - 9-kip FWD pavement surface deflection (mils) at 36 inch offset

The Illinois Department of Transportation conducted Falling Weight Deflectometer (FWD) tests on several two-lane road flexible pavements throughout the state of Illinois. The projects included many of the major

soil series that predominate in Illinois. Table 1 summarizes the soil series and their occurrence in Illinois. Note the coverage is about 49%.

Figure 3 shows the locations of the Illinois counties involved. The flexible pavements tested are listed below:

Bond County Highway 3

Edwards County: IL 15 (west of Albion)

Jersey County: Highway 9 and Highway 25

Livingston County: Ocoya Road

Marion County Highway 23

Mercer County Highway 16

Peoria County Highway 60

Perry County: County Highway 12; County Highway 21; and IL Highway 154

Piatt County Highway 5

Sangamon County: New City Road

Williamson County Highway 3

Tables 2 and 3 present pertinent data for each project. FWD tests (9-kip loading) were conducted in the outer wheel path at intervals ranging from 50 to 200 feet along the roadway. FWD test locations were "staggered" when the "other lane" was tested. The FWD test station location and a county soil map were used to group the FWD test results into "soil series segments." The road test sections included from 3 to 11 different soil series, with many soil series occurring more than once.

Subgrade moduli (E_{Ri}) were calculated using the appropriate FWD algorithm (Equation 1, 2, 3, or 4). The FWD test data were processed by a PC computer program which generated average subgrade E_{Ri} values for the particular set of data. In addition to the average E_{Ri} values, the

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standard deviation, coefficient of variation, and E_{Ri} percentile distribution values were computed. A typical output is shown in Appendix A. The data were subdivided and the average E_{Ri} for each soil series segment was calculated. Individual sections were then recombined with other sections of the same soil series, and an average E_{Ri} was found for that soil series within a project. Results for the individual soil series segments and the project wide soil series averages are presented in Appendix B.

"F-tests" were used to determine if the average E_{Ri} values were different. A significance level of $\alpha = 0.05$ was checked. Several types of comparisons were made. The most basic was the comparison of soil series segments within a project. Similar soil series segments within a project were compared using the average E_{Ri} values, standard deviations and number of FWD tests in each segment. The results of these comparisons are shown in Appendix B.

The next level of comparison was among soil series segments from different projects. This was carried out on two levels. The first of these levels used the individual soil series segments from the various projects. The second level used the project-wide soil series averages as the basis of comparison. Results of the comparisons are presented in Appendices C and D respectively.

In all cases, an average E_{Ri} value for an individual segment was only used for comparison purposes if it contained three or more individual FWD tests. However, all soil series segments were used in determining the average E_{Ri} value for that soil series on a project-wide basis.

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RESULTS

Many different soil series appeared within a project. The soil series that occurred are listed by project in Appendix B. The total number of individual soil series was 61. Multiple segments of the same soil series within a project occurred 55 times. Comparisons were made of these 55 individual occurrences.

For example, Williamson County had 8 Ava (#14) soil series segments along Highway 3. Of those 8, 6 had three or more FWD tests, and were eligible for comparison. The average E_{Ri}, standard deviation and number of samples for those 6 gave a calculated "F-value" of 0.55. This F-value is not significant at $\alpha = 0.05$. Thus, it is concluded that the E_{Ri} of the soil series segments are not significantly different.

Using this type of comparison, 39 of the 55 (71%) soil series did not show a significant difference at $\alpha = 0.05$. Sixteen of the 55 (29%) comparisons did indicate a significant difference in average E_{Ri} values. The comparisons with a significant difference are listed in Table 4.

The next comparison considered soil series segments which occurred in different projects. There were 22 soil series which occurred in more than one project. These soil series were compared on two different levels using the "F-test."

The first project-project comparison level was based on the average E_{Ri} values for each individual soil series segment in all the projects for a particular soil series. The summary of these data is shown in Appendix C. The data are divided by soil series. The individual segments are listed for the various projects. Out of the 22 soil series compared, eleven of them (50%) had no significant difference at $\alpha = 0.05$.

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For the second comparison level the project-wide soil series averages were used. These values are summarized in Appendix D. They are also grouped together by soil series. Out of the 22 soil series which appeared in two or more projects, eleven of them (50%) had no significant difference at $\alpha = 0.05$.

To further investigate the differences among soil series segment E_{Ri} means showing a significant difference ($\alpha = 0.05$), "t-Test" based least significant difference (LSD) comparisons were made. The LSD comparisons identify those E_{Ri} averages that are significantly different. The LSD results are summarized in Appendix E. In most instances, many of the soil series segment E_{Ri} averages in the comparisons do not significantly differ.

In addition to the average soil series E_{Ri} values, the percentile distribution of E_{Ri} values making up the average is also of interest. The FWD data analysis PC program generates a percentile distribution table showing the "percent greater than" for ten increments of the E_{Ri} values. These distributions add to the interpretation of the average E_{Ri} values. For instance (see Appendix F), the average E_{Ri} value for Hoyleton soils in Bond county is 6.9 ksi. However, the distribution shows that 6.9 ksi falls at the 39 percentile. Thus 61% of the individual values for Hoyleton soils were lower than the average value of 6.9 ksi.

Appendix F summarizes data for the individual soil series' percentile distributions and average E_{Ri} values. Figures 4 and 5 show relations between 50 percentile and 85 percentile E_{Ri} and "average" E_{Ri} values, respectively. The average is approximately equal to the 50 percentile value and the 85 percentile value can be estimated from the average based on the regression equation shown in Figure 5. As would be expected (see Figure 6), the relation between the 100 percentile and average E_{Ri} value is not good. It is emphasized that the 100 percentile value is the lowest E_{Ri}.

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Obviously, inconsistent and aberrant individual E_{Ri} values will control this low value.

The percentile distribution concept addresses a problem associated with the statistically based approach. For example, an average E_{Ri} value minus two standard deviations (approximately an 85 percentile value) can be negative. This is obviously not possible! The percentile distributions provide realistic lower limits and provide a better indication of typical E_{Ri} values.

Average E_{Ri} values for entire projects are also of interest. Table 5 presents these values. In each case, an average E_{Ri} value was found for the entire project based on the E_{Ri} for every individual soil series segment that had three or more FWD tests conducted. Standard deviation and coefficient of variation values were also calculated. The project average E_{Ri} values ranged from 3.1 ksi in Mercer County to 10.3 ksi in Marion County.

The "overall" average E_{Ri} value for all of the projects was 7.5 ksi with a standard deviation of 2.5. This average is based on the 255 individual soil series segments in the projects. Tabular and graphical presentations of the "overall E_{Ri}" percentile distribution are shown in Table 6 and Figure 7.

DISCUSSION AND COMMENTS

It is apparent that soil series can be used to characterize subgrade resilient moduli. No significant differences ($\alpha = 0.05$) were found in 71% of the "project level" comparisons. In soil series comparisons at the project-project level, no significant differences were noted in 50% of the cases. Table 4 and Appendix E indicate the comparisons where "statistically

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significant diff   .s" were identified. Note that the "statistically

significant differences" are small. Figure 8 shows the distribution of the

soil series segments with LSD differences expressed as the average

E_{Ri}/Segment E_{Ri}. The boundary limits are shown at +/-20% of the average

E_{Ri}. A cumulative distribution representation of the data is shown in

Figure 9. A +/-20% E_{Ri} difference would translate to 1.5 ksi for a 7.5 ksi

E_{Ri} average.

The differences are not of practical engineering importance in pavement

design. Consider for example, that (wet of optimum) a 1% increase in

gravimetric moisture content will approximately decrease E_{Ri} as indicated

below (5).

USDA TEXTURAL CLASSIFICATION	E_{Ri} DECREASE/1% MOISTURE INCREASE (ksi/%)
clay, silty clay, and silty clay loam	0.7
silt loam	1.5
loam	2.1

SUMMARY

Soil series location information from modern county soil reports and maps (available from USDA Soil Conservation Service) can be correlated to subgrade soil resilient moduli (E_{Ri}) values back-calculated from falling weight deflectometer (FWD) surface deflection basin data. Data from over fifty miles of flexible pavements throughout Illinois are included in this study. The soil series included in the study account for approximately 49% of the surficial soils of Illinois. In 71 percent of the comparisons, there are not statistically significant differences in average subgrade moduli values for given soil series segments. When there is a statistically significant difference, it generally is small and not of practical engineering importance in a pavement design context.

The use of soil series - subgrade E_{Ri} data based on FWD studies can greatly expedite and simplify the establishment of subgrade E_{Ri} values for pavement analysis and design and similar types of horizontal construction activities. If data are not available for a particular soil series, soil series - E_{Ri} data can be easily developed.

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TABLE 1

SOIL SERIES INCLUDED IN THE STUDY

Soil Number	Soil Name	% Area
293	Andres	0.530
232	Ashkum	0.649
259	Assumption	0.091
7	Atlas	0.434
14	Ava	1.123
929	Ava/Hickory	0.126
382	Belknap	1.565
5	Blair	1.273
13	Bluford	2.369
108	Bonnie	0.949
134	Camden	0.562
171	Catlin	1.147
2	Cisne	2.944
991	Cisne/Huey	0.031
257	Clarksdale	0.665
18	Clinton	1.750
428	Coffeen	0.083
620	Darmstadt	0.186
916	Darmstadt/Oconee	0.069
119	Elco	0.141
280	Fayette	2.147
154	Flanagan	3.307
301	Grantsburg	0.504
331	Haymond	0.231
8	Hickory	3.208
814	Hickory/Ava	0.013
900	Hickory/Wells	nil
214	Hosmer	1.905
3	Hoyleton	1.324
912	Hoyleton/Darmstadt	0.056
43	Ipava	1.808
275	Joy	0.077
17	Keomah	0.812
451	Lawson	1.985
196	Lemond	*
59	Lisbon	0.351
27	Miami	0.111
69	Milford	0.326
41	Muscatine	2.439
113	Oconee	0.472
330	Peotone	0.164
220	Plattville	0.061
277	Port Byron	0.123

(*) Not correlated in Illinois

Soil Number	Soil Name	% Area
335	Robbs	0.036
279	Rozetta	0.660
16	Rushville	0.075
322	Russell	0.206
68	Sable	1.057
274	Seaton	0.232
943	Seaton/Timula	0.042
258	Sicily	0.735
164	Stoy	0.863
278	Stronghurst	0.150
19	Sylvan	0.412
294	Symerton	0.227
36	Tama	3.475
333	Wakeland	0.732
165	Weir	0.277
12	Wynoose	0.975
291	Xenia	0.170
340	Zanesville	0.313

TOTAL   **48.748**

TABLE 2

SUMMARY OF PAVEMENT CROSS-SECTIONS

PROJECT	SURFACES		BASES	
	Thickness (in.)	Type	Thickness (in.)	Type
Bond Co.		Surface Treatment	4 –8	Granular Base
IL 15	12	Asphalt Concrete		
Jersey 9	2	Asphalt Concrete	7	Crushed Stone
Jersey 25		Surface Treatment	8	Granular Base
Livingston Co.	3	Asphalt Concrete	12	Granular Base
Marion Co.		Surface Treatment	7	Granular Base
Mercer Co.(*)	4.5	Asphalt Concrete	8	Granular Base
Mercer Co.(**)	3.5	Asphalt Concrete	10.5	Granular Base
New City Road	3	Asphalt Concrete	15.5	Crushed Stone
Peoria Co.		Surface Treatment	6	Crushed Stone
Perry 12		Surface Treatment	9.5	Granular Base
Perry 21		Surface Treatment	11	Crushed Stone
Perry 154	2	Asphalt Concrete	6+	Granular Base
Piatt Co.		Surface Treatment	8	Granular Base
Williamson Co.	3	Asphalt Concrete	10	Crushed Stone

(*) Sta 3+60 to 40+00   and   Sta 85+00 to 193+60   (**) Sta 40+00 to 85+00

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TABLE 3

SUMMARY SHEET OF ALL PROJECTS AND PERTINENT CHARACTERISTICS

PROJECT	DATE TESTED	FWD EQUATION *	TEST INTERVAL (ft.)	PROJECT LENGTH (miles)	AIR TEMP (F)	SURFACE TEMP (F)
Bond 3	May 28, 1987	#1	100	5.94	82	78
Il 15	April 29, 1987	#4	125	4.35	80	100
Jersey 9	June 10, 1987	#1	100	4.31	80	104
Jersey 25	April 20, 1987	#1	100	2.95	82	102
Livingston Co.	October 13, 1987	#2	50	2.00	50	65
Marion 23	April 28, 1987	#2	100	3.48	67	104
Mercer 16	May 12, 1987	#2	200	3.66	70	102
New City Road	March 26, 1986	#3	200	1.75	55	62
New City Road	October 4, 1985	#3	200	1.75	58	67
Peoria 60	June 18, 1987	#1	100	2.52	85	106
Perry 12	June 24, 1987	#3	100	2.68	80	88
Perry 21	August 26, 1987	#1	100	4.37	77	83
Perry 154	June 24, 1987	#2	100	3.15	90	110
Piatt 5	March 31, 1987	#1	125	3.62	37	60
Williamson 3	April 17, 1987	#1	100	2.35	55	58

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TABLE 4

LIST OF SOIL SERIES WITH SIGNIFICANT DIFFERENCES AT $\alpha = 0.05$

SECTION #	PROJECT	SOIL NAME	Avg Eri/Segment Eri(Stand. Dev.)	Eri AVERAGE(ksi)
1	Bond Co.	Hoyleton	1.10 (0.26)	6.9
2	Bond Co.	Cisne	0.95 (0.21)	4.9
3	Il 15	Belknap	1.00 (0.24)	8.9
4	Jersey 25	Keomah	1.24 (0.67)	6.8
5	Livingston Co.	Andres	1.00 (0.28)	7.3
6	Marion Co.	Hoyleton	1.13 (0.31)	11.8
7	Marion Co.	Cisne	0.98 (0.17)	8.6
8	New City Road	Ipava	1.00 (0.14)	7.3
9	Perry 12	Stoy	0.98 (0.41)	5.1
10	Perry 12	Oconee	1.10 (0.42)	5.9
11	Perry 21	Stoy	1.06 (0.27)	7.6
12	Perry 154	Hoyleton	1.12 (0.33)	6.1
13	Perry 154	Hoyleton/Darmstadt	1.10 (0.42)	5.9
14	Perry 154	Bluford	1.12 (0.31)	7.4
15	Piatt Co.	Ipava	1.10 (0.42)	5.3
16	Piatt Co.	Flanagan	1.08 (0.27)	7.8

AVERAGE = 1.07 (0.31)

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TABLE 5

PROJECT Eri AVERAGES

Project	Avg Eri(ksi)	St. Dev	Coef. Var.	High Eri Value(ksi)	Low Eri Value(ksi)	Num of Diff Soil Segments	Num of Diff Soil Series
Bond 3	7.9	2.6	32.9	14.4	4.8	22	6
Il 15	8.8	2.2	25.0	15.3	4.8	26	9
Jersey 9	7.5	1.6	21.3	10.2	3.7	18	10
Jersey 25	8.7	3.4	39.1	14.9	2.9	21	8
Livingston Co.	7.2	2.7	37.5	11.9	4.1	9	6
Marion 23	10.3	2.5	24.3	14.8	7.4	17	6
Mercer 16	3.1	1.1	35.5	5.3	1.8	8	6
New City (Mar 86)	8.1	1.4	17.3	10.3	6.7	6	3
New City (Oct 85)	8.6	1.5	17.4	10.8	6.7	5	3
Peoria 60	5.3	1.6	30.2	9.0	3.0	16	9
Perry 12	6.8	2.5	36.8	11.7	3.2	21	8
Perry 21	7.2	1.3	18.1	9.6	5.2	21	4
Perry 154	6.8	1.4	20.6	9.2	4.1	30	11
Piatt 5	7.0	1.4	20.0	8.9	3.8	21	8
Williamson 3	8.7	1.0	11.5	10.3	6.8	14	4
Average of all Projects=	7.5			11.1	4.6	17	7

TABLE 6

PERCENTILE DISTRIBUTION FOR
SUMMER 87 FWD DATA

| % GREATER	Eri (ksi)
100.0	1.8
90.0	4.5
80.0	5.6
70.0	6.5
60.0	6.9
50.0	7.5
40.0	8.0
30.0	8.5
20.0	9.0
10.0	10.4
0.0	15.3

Average Eri Value = 7.6 ksi

Standard Deviation = 2.5 ksi
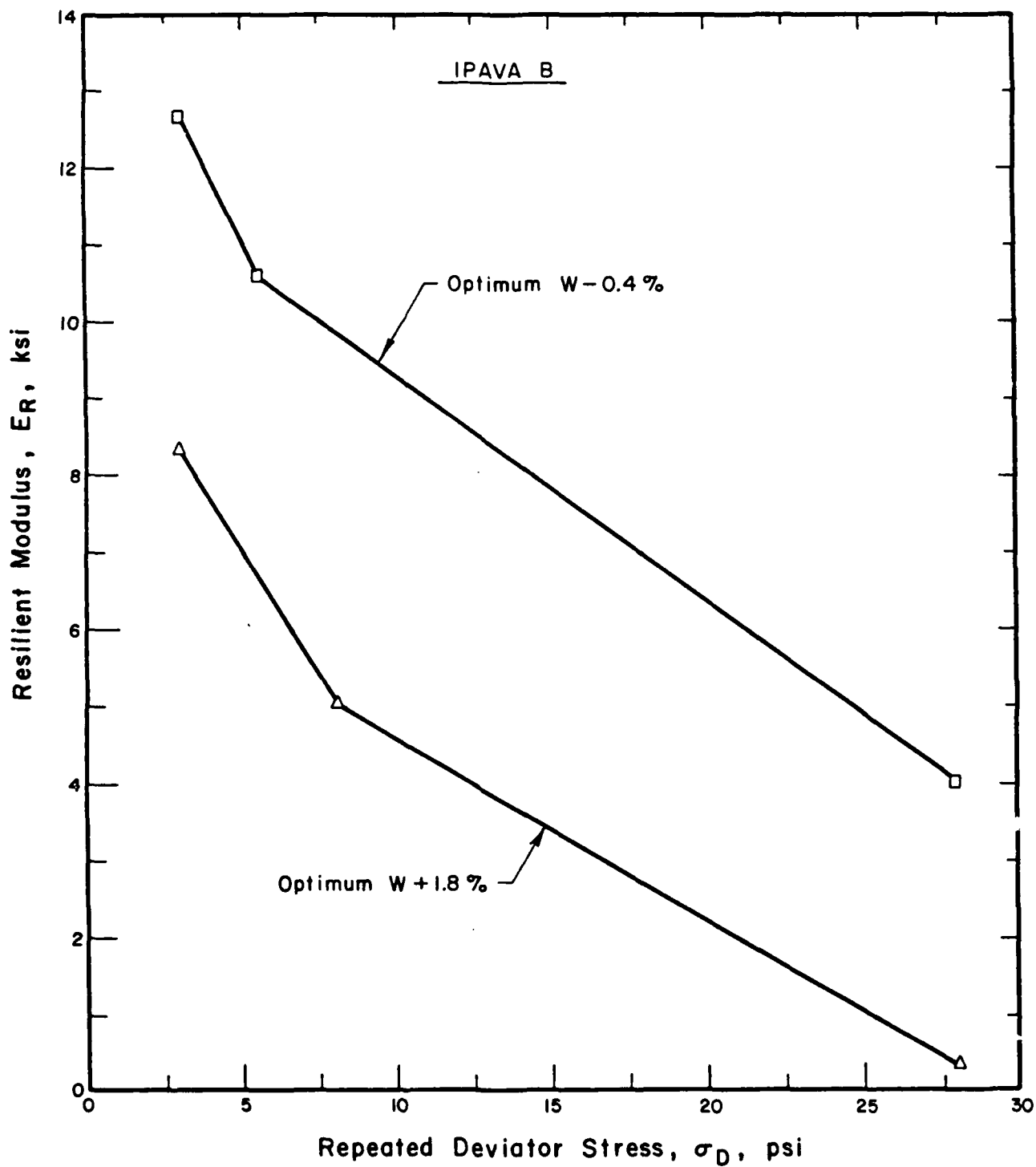
Figure 1.   Resilient Modulus-Deviator Stress Relations for Ipava B.
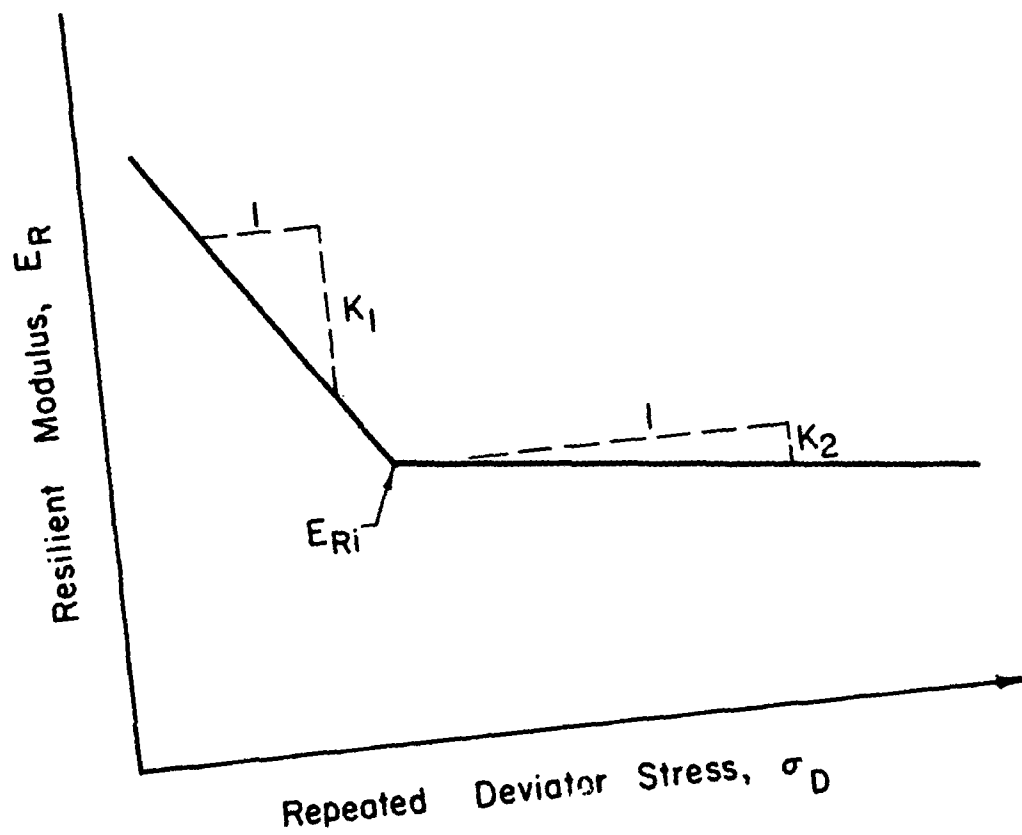
Figure 2. Typical Resilient Modulus-Deviator Stres Relation for Fine-Grained Soils.

Figure 3. Project Locations in Illinois.

21
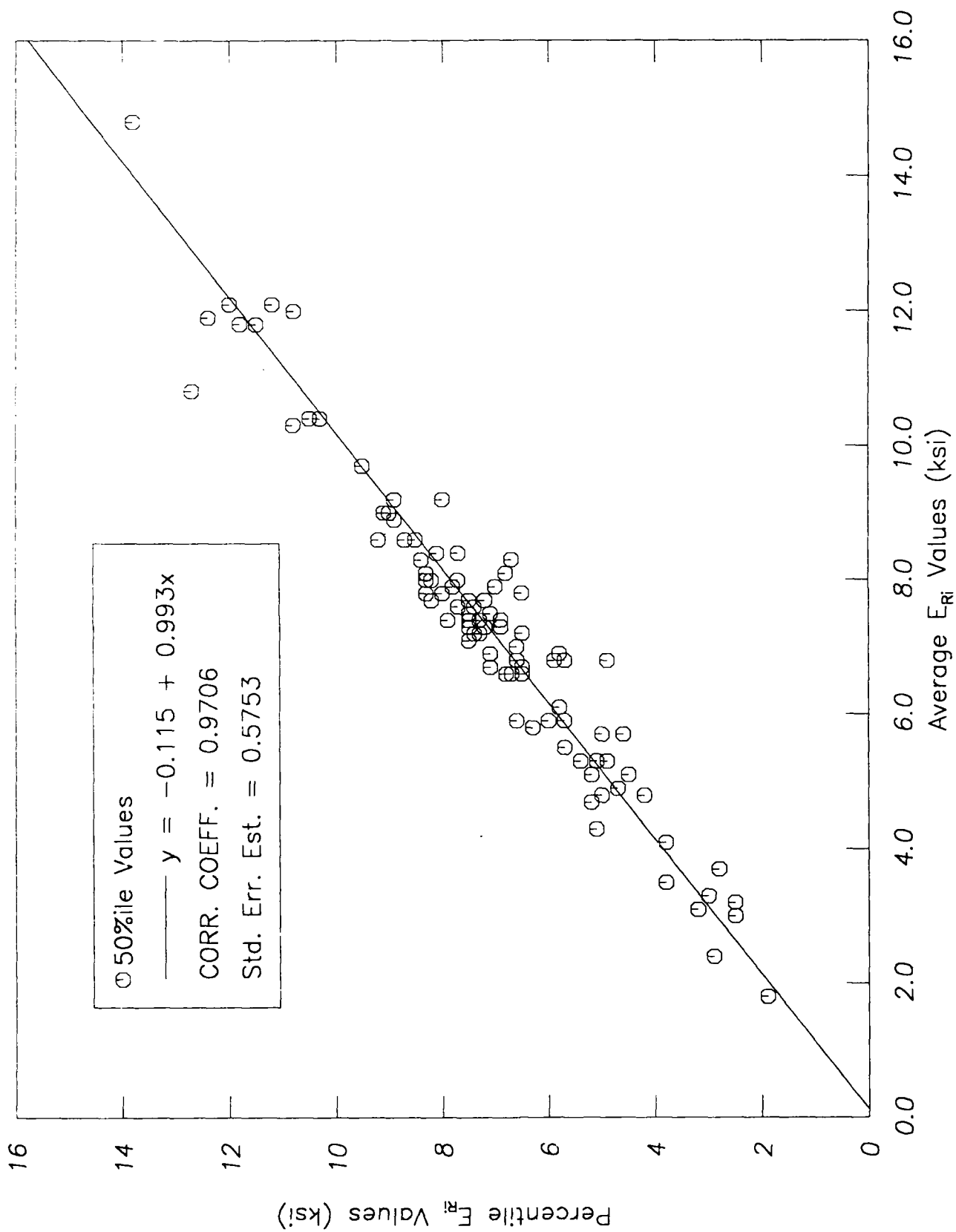
Figure 4.   50 Percentile E_{Ri} – Average E_{Ri} Relation.

Percentile E_{Ri} Values (ksi)

Average E_{Ri} Values (ksi)

⊙ 50%ile Values
—— $y = -0.115 + 0.993x$
CORR. COEFF. = 0.9706
Std. Err. Est. = 0.5753

22
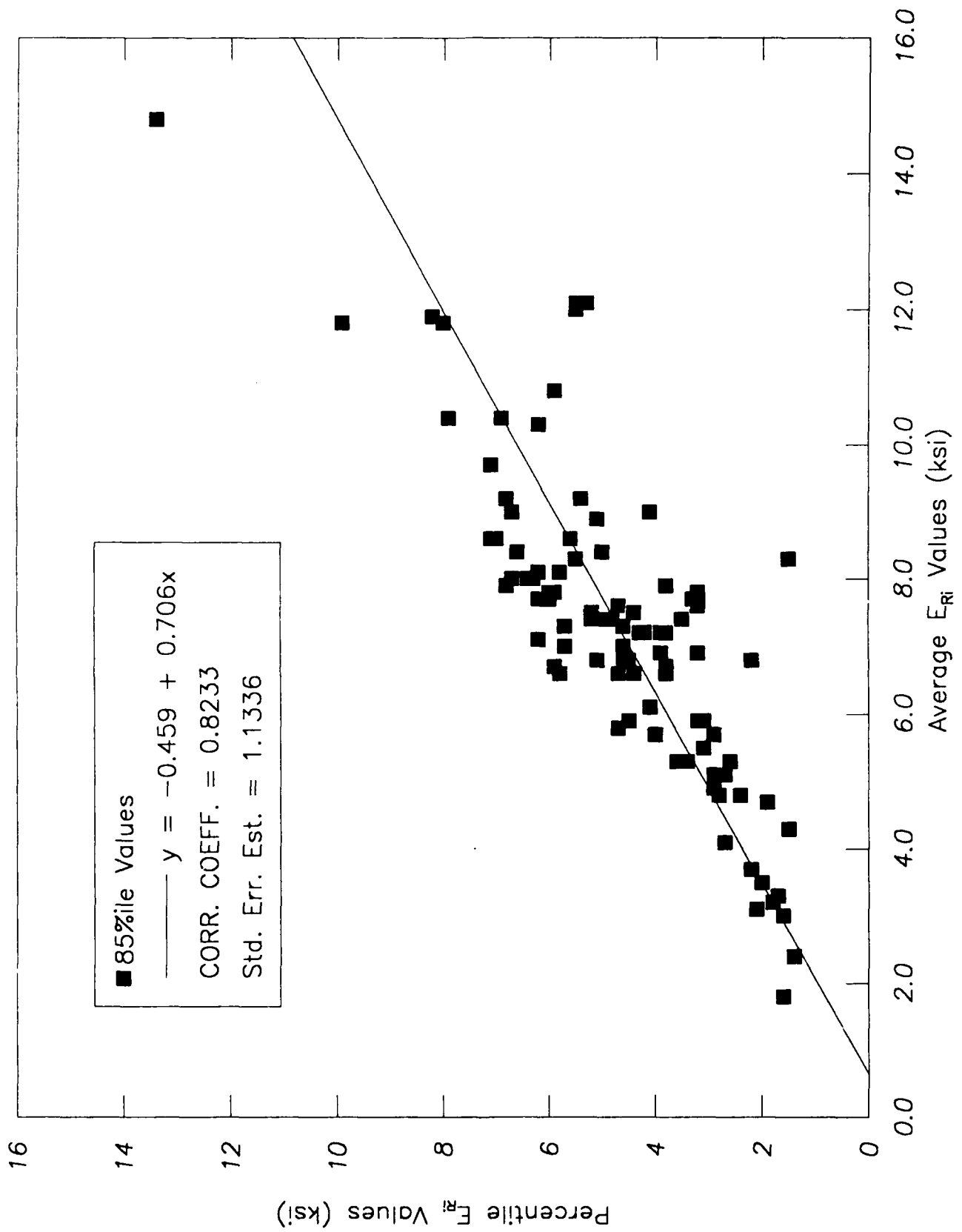
Figure 5. 85 Percentile E_{Ri} - Average E_{Ri} Relation.

Legend within figure:

■ 85%ile Values
—— $y = -0.459 + 0.706x$
CORR. COEFF. = 0.8233
Std. Err. Est. = 1.1336

X-axis: Average E_{Ri} Values (ksi)

Y-axis: Percentile E_{Ri} Values (ksi)
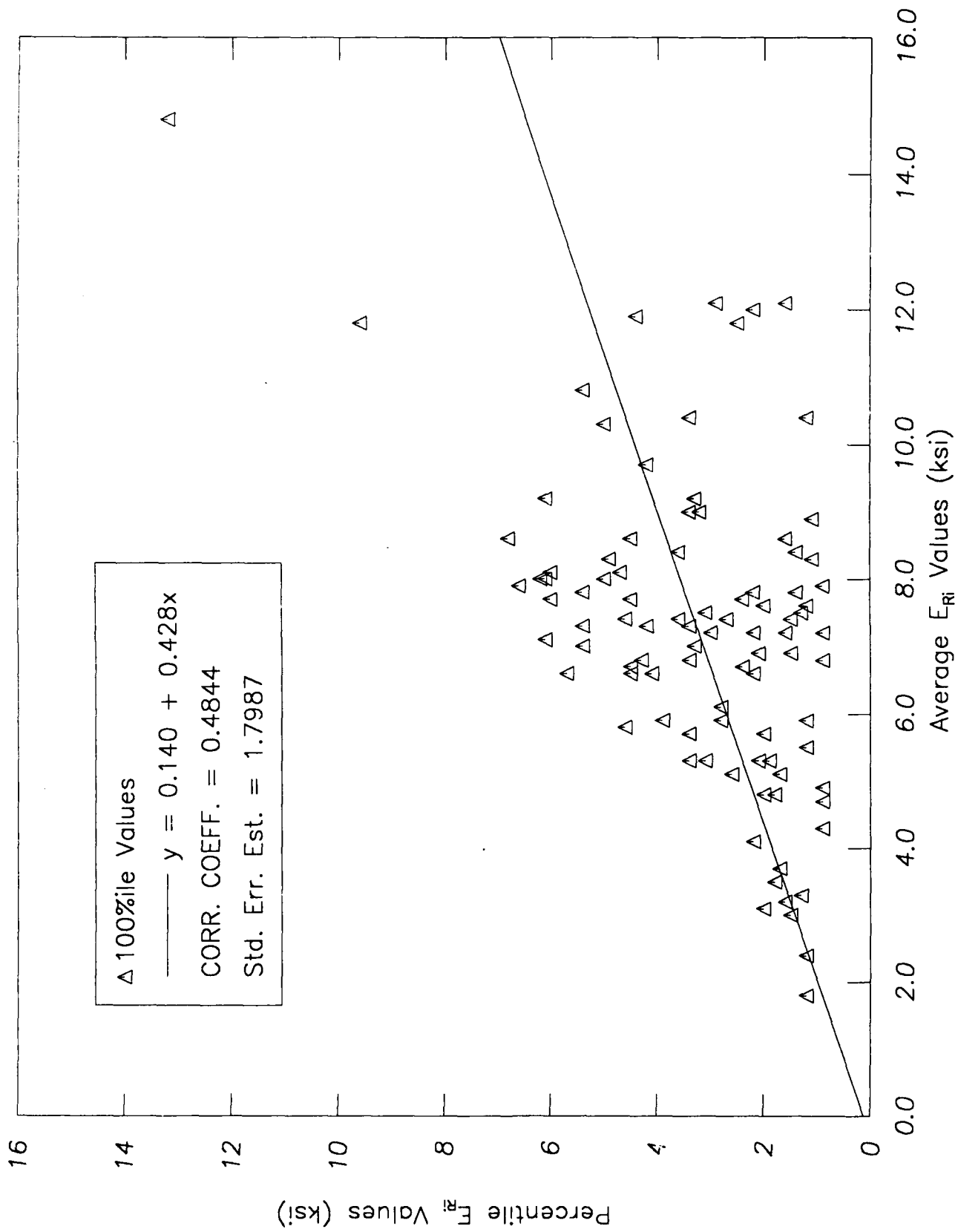
Figure 6. 100 Percentile E_{Ri} - Average E_{Ri} Relation.

The plot shows Percentile E_{Ri} Values (ksi) on the vertical axis versus Average E_{Ri} Values (ksi) on the horizontal axis.

△ 100%ile Values
— $y = 0.140 + 0.428x$
CORR. COEFF. = 0.4844
Std. Err. Est. = 1.7987

24
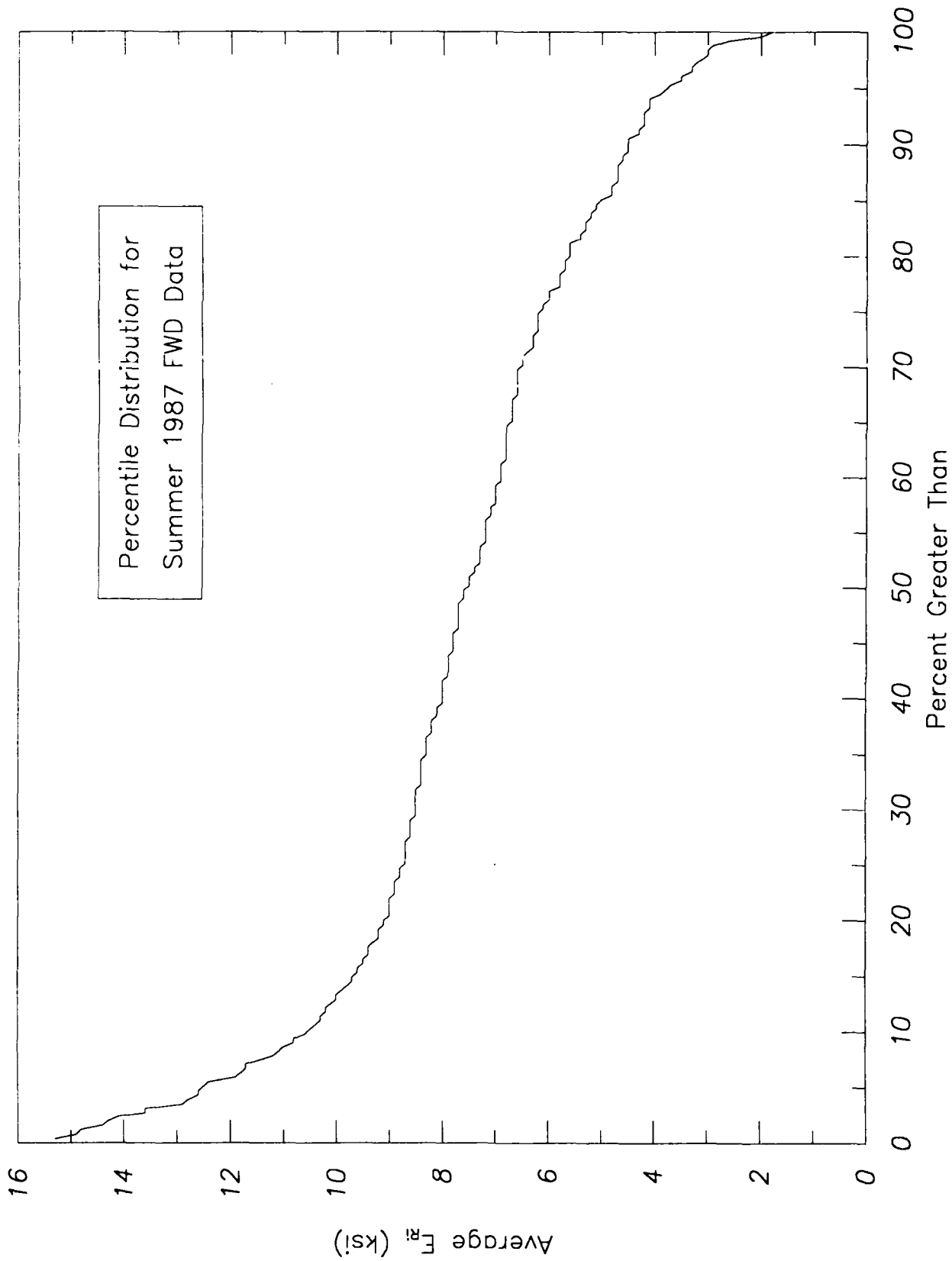
Figure 7 E_{Ri} - Percentile Distribution Data for Summer 1987 FWD Data.

Soil Series Segments within +/- 20%
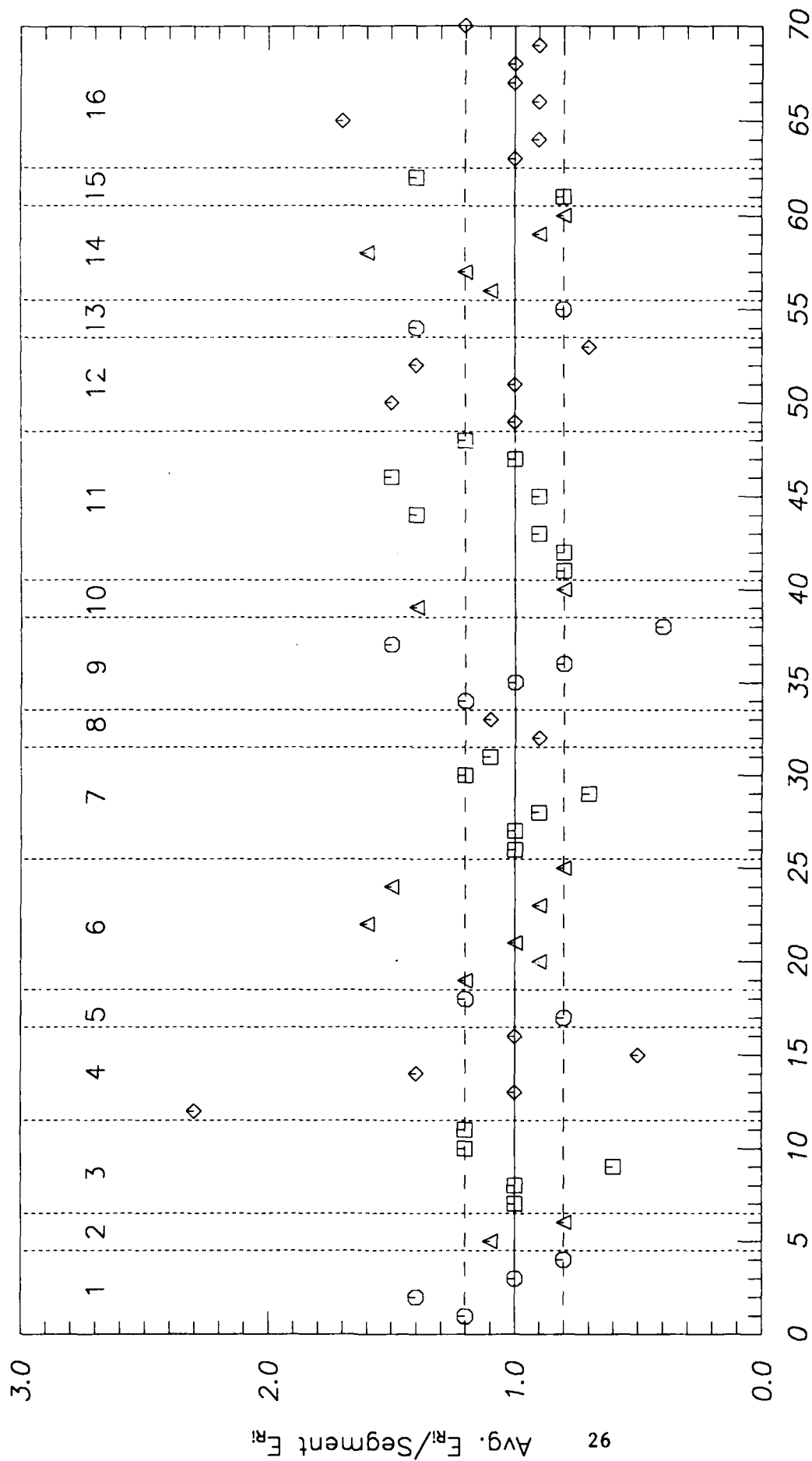
Figure 8. Average E_{Ri}/Segment E_{Ri} Ratios (see Table 4).
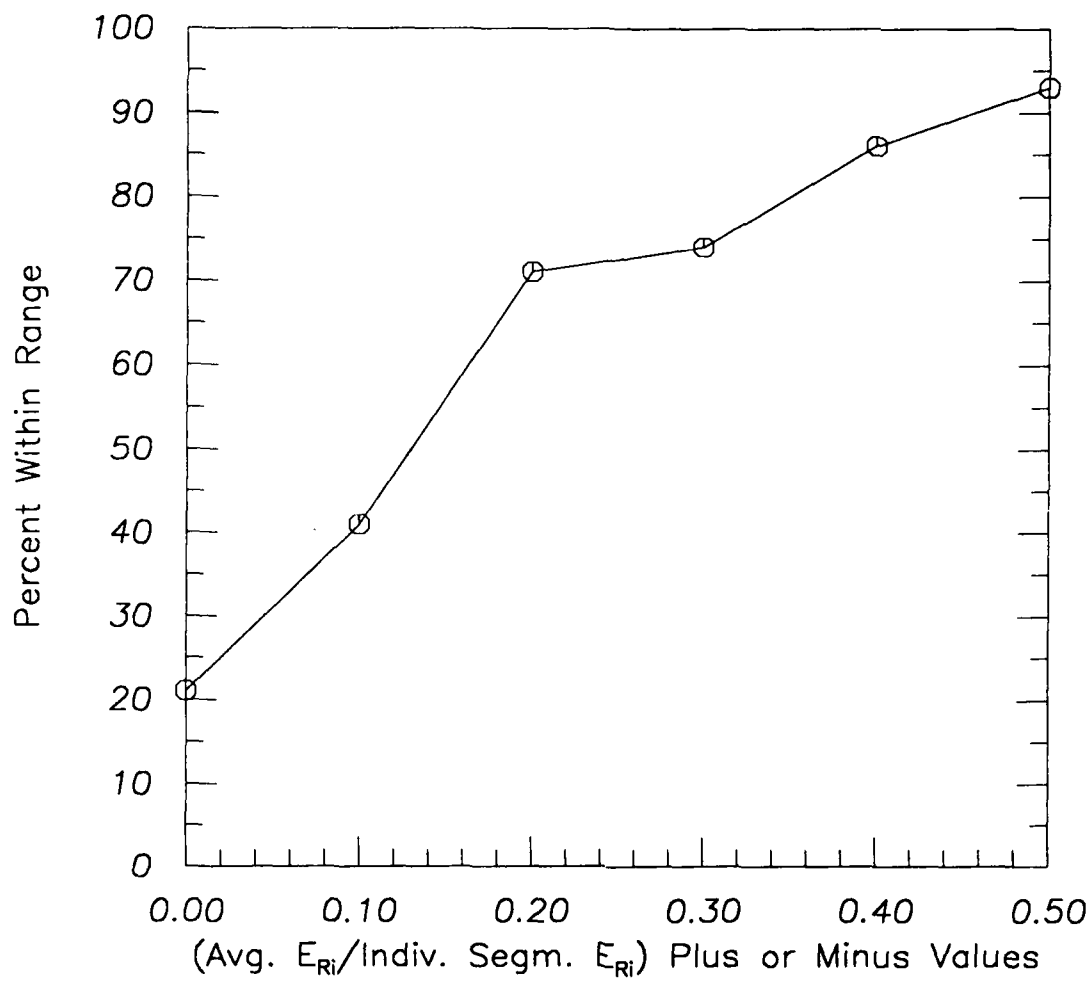
Figure 9.   Distribution of Average E_{Ri}/Segment E_{Ri} Ratios
(+/- Values)

APPENDIX A

TYPICAL FWD ANALYSIS OUTPUT

Appendix A is a sample output generated by the FWD data analysis program. The output consists of a listing of the "normalized" FWD testing data by station, and a statistical summary of the data. A percentile distribution for the data is also shown. The example is for all of the Bluford soil series segments in the Williamson County project.

```
*************************************************************
*                                                           *
*          ANALYSIS OF DATA FROM THE FALLING WEIGHT         *
*                      DEFLECTOMETER                        *
*                                                           *
*   NORMALIZED FORCE  = 9000. LB                            *
*   PAV. TYPE:  FOR SURFACE TREATMENTS                      *
*   PAVEMENT NAME: COUNTY HIGHWAY 3                         *
*   DATE: APRIL 17, 1987                                    *
*   AIR TEMP.:  55     PAV. TEMP.:  58                      *
*   REMARKS: BLUFORD SILT LOAM                              *
*                                                           *
*...........................................................*
*                                                           *
*       D0     DEFLECTION AT R= 0 IN. FROM LOAD (MILS)      *
*                                                           *
*       D1     DEFLECTION AT R=12 IN. FROM LOAD (MILS)      *
*                                                           *
*       D2     DEFLECTION AT R=24 IN. FROM LOAD (MILS)      *
*                                                           *
*       D3     DEFLECTION AT R=36 IN. FROM LOAD (MILS)      *
*                                                           *
*       AREA   AREA=6(D0+2D1+2D2+D3)/D0 (INCHES)            *
*                                                           *
*       ERI    ERI=24.2-5.71*D3+0.35*D3*D3 (KSI)            *
*                                                           *
*       >>>     FOR SURFACE TREATMENTS          <<<         *
*                                                           *
*************************************************************


* * * * * * * * * * * * * *   NORMALIZED DATA   * * * * * * * * * * * * * * * * *


STATION    D0      D1      D2      D3      AREA    ERI     COMMENTS   TIME   WHP
===============================================================================
   49.61   27.61   16.56   8.26    4.41    17.75   5.83    NB0   0    1012    1
   50.61   14.90   10.48   6.96    4.53    21.88   5.52    SB0   0    1013    1
   51.61   18.04   11.52   6.37    3.54    19.07   8.38    NB0   0    1013    1
   52.61   13.21    9.94   6.96    4.56    23.43   5.44    SB0   0    1014    1
   53.61   17.53   11.42   6.71    4.11    19.82   6.63    NB0   0     849    1
   54.61   21.65   13.60   7.73    4.36    19.03   5.95    SB0   0     850    1
   55.61   19.00   12.55   6.93    3.72    19.47   7.80    NB0   0     851    1
   56.61   19.37   12.23   6.48    3.42    18.65   8.78    SB0   0     852    1
  115.61   15.18   11.22   7.10    4.20    22.14   6.40    NB0   0     944    1
  116.61   13.85    9.13   5.11    2.90    19.59  10.58    SB0   0     945    1
  117.61   12.03    8.99   5.82    3.64    22.58   8.05    NB0   0     946    1
  118.61   16.58   11.26   6.48    3.61    20.15   8.15    SB0   0     918    1
  119.61   11.26    8.48   5.47    3.40    22.69   8.83    NB0   0     919    1
  124.52    9.38    7.58   5.90    4.46    26.10   5.70    CN0   0     923    3
```

* * * * * * * * * * * * * * S T A T I S T I C S * * * * * * * * * * * * * * * * *

	D0 (MILS)	D1 (MILS)	D2 (MILS)	D3 (MILS)	AREA (INCHES)	ERI (KSI)
MEAN	16.4	11.1	6.6	3.9	20.9	7.3
STA DEV	4.7	2.3	0.8	0.5	2.3	1.6
COV(%)	28.7	20.8	12.9	13.3	11.1	21.6

NUMBER OF SAMPLES 14

*** ERI % GREATER THAN DATA ***

ERI (KSI)	% GREATER
5.44	100.00
5.96	64.29
6.47	57.14
6.98	50.00
7.50	50.00
8.01	42.86
8.52	21.43
9.04	7.14
9.55	7.14
10.06	7.14
10.58	0.00

APPENDIX B

PROJECT LEVEL ANALYSES

Appendix B presents FWD analysis data for each project. The data are the FWD test date, the number of the E_{Ri} regression equation used, the length of the project, and distance between test locations. The air temperature and the pavement surface temperature at the time of testing are also included.

The data are grouped according to soil series. Each soil series has an average E_{Ri} value, standard deviation, coefficient of variation and number of samples for that entire soil series. The same data are also included for each individual soil series segment with three or more samples.

An "F-value" for all soil series segments within the project is also included. This value indicates whether or not there is a significant difference at $\alpha = 0.05$.

BOND 3
May 28, 1987
Eqn. #1
Surface Treatment

5.94 miles
100' interval
Air temp 82
P.S. temp 78

Soil #	Soil Series	Sign. Diff. at α = 0.05(**)	Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
3	Hoyleton	**	AVERAGE	6.9	3.7	62	53.6	4.02
			1	5.6	3.1	15	55.4	
			2	4.8	1.6	10	33.3	
			3	7.2	4.2	16	58.3	
			4	8.9	3.8	19	42.7	
2	Cisne	**	AVERAGE	4.9	2.0	71	40.8	9.48
			1	4.5	1.9	56	42.2	
			2	6.2	1.8	15	29.0	
13	Bluford		AVERAGE	7.9	4.0	65	50.6	2.34
			1	6.2	3.9	4	62.9	
			2	6.9	3.1	21	44.9	
			3	8.9	4.3	8	48.3	
			4	8.2	4.0	26	48.8	
			5	4.8	6.2	3	129.2	
			6	13.6	1.9	3	14.0	
7	Atlas		AVERAGE	8.3	7.9	4	95.2	N. A.
14	Ava		AVERAGE	8.4	3.6	81	42.9	1.64
			1	8.5	2.5	11	29.4	
			2	8.5	3.2	13	37.6	
			3	7.0	2.2	6	31.4	
			4	6.6	1.1	5	16.7	
			5	8.7	4.2	17	48.3	
			6	9.7	3.8	17	39.2	
			8	5.8	3.9	9	67.2	
8	Hickory		AVERAGE	12.1	7.1	15	58.7	0.58
			1	11.2	6.9	11	61.6	
			2	14.4	8.2	4	56.9	

B-2

IL 15
April 29. 1987
Eqn. #4
Full depth AC

4.35 miles
125' intervals
Air temp 80
P.S. temp 100

Soil #	Soil Series	Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
3	Hoyleton	AVERAGE	7.7	2.0	9	26.0	N. A.
13	Bluford	AVERAGE	7.2	2.5	39	34.7	0.48
		1	6.8	2.2	13	32.4	
		2	6.8	2.2	7	32.4	
		3	7.9	2.4	12	30.4	
		4	7.5	3.7	7	49.3	
335	Robbs	AVERAGE	6.6	2.7	11	40.9	0.11
		1	6.7	0.0	3	0.0	
		3	6.2	2.5	4	40.3	
14	Ava	AVERAGE	10.4	3.2	13	30.8	N. A.
428	Coffeen	AVERAGE	8.6	1.8	3	20.9	N. A.
340	Zanesville	AVERAGE	10.4	3.1	32	29.8	0.32
		3	10.5	1.1	6	10.5	
		9	10.1	2.5	6	24.8	
		12	11.0	1.7	5	15.5	
301	Grantsburg	AVERAGE	9.7	2.9	36	29.9	1.69
		1	9.2	0.9	3	9.8	
		2	8.7	3.6	3	41.4	
		3	12.8	2.4	3	18.8	
		5	8.4	1.2	4	14.3	
		6	8.0	2.5	6	31.3	
		7	11.4	3.1	6	27.2	
		8	7.9	4.5	4	57.0	
		9	10.0	1.3	5	13.0	
5	Blair	AVERAGE	4.8	2.7	5	56.3	N. A.

Sign. Diff. at α = 0.05(* *)

B-3

IL 15
April 29. 1987
Eqn. #4
Full depth AC

4.35 miles
125' intervals
Air temp 80
P.S. temp 100

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
382	Belknap	AVERAGE	* *	8.9	3.4	44	38.2	3.77
		2		9.0	2.8	20	31.1	
		4		8.7	3.7	7	42.5	
		6		15.3	2.1	3	13.7	
		7		7.2	2.5	3	34.7	
		8		7.6	3.4	3	44.7	

B-4

JERSEY 9
June 10, 1987
Eqn. #1
Surface treatment

4.31 miles
100' intervals
Air temp. 80
P.S. temp. 104

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *) Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
18	Clinton	AVERAGE	3.7	1.8	12	48.6	N. A.
258	Sicily	AVERAGE	7.4	2.2	24	29.7	2.78
		1	6.9	2.3	16	33.3	
		2	8.4	1.5	8	17.9	
41	Muscatine	AVERAGE	5.1	2.0	4	39.2	N. A.
257	Clarksdale	AVERAGE	8.0	1.6	3	20.0	N. A.
279	Rozetta	AVERAGE	7.2	3.1	114	43.1	2.05
		1	9.3	3.7	8	39.8	
		2	6.7	3.2	15	47.8	
		3	8.5	2.6	14	30.6	
		4	6.8	2.7	57	39.7	
		5	6.8	3.7	20	54.4	
278	Stronghurst	AVERAGE	8.1	3.3	8	40.7	2.71
		1	9.4	3.6	5	38.3	
		2	5.8	1.0	3	17.2	
8	Hickory	AVERAGE	9.2	5.2	20	56.5	0.75
		1	6.5	0.6	4	9.2	
		2	10.2	6.5	12	63.7	
		3	9.1	0.5	4	5.5	
333	Wakeland	AVERAGE	8.3	2.2	6	26.5	N. A.
331	Haymond	AVERAGE	7.8	2.7	5	34.6	N. A.
134	Camden	AVERAGE	8.0	1.7	4	21.3	N. A.

JERSEY 25
April 20, 1987
Eqn. #1
Surface treatment

2.95 miles
100' intervals
Air temp. 82
P.S. temp. 102

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
8	Hickory	AVERAGE		12.1	5.4	52	44.6	1.45
		1		8.3	3.2	3	38.6	
		2		8.7	3.9	4	44.8	
		3		14.9	6.6	12	44.3	
		4		12.9	5.0	6	38.8	
		5		11.7	5.3	15	45.3	
		6		11.1	3.8	9	34.2	
18	Clinton	AVERAGE		12.0	6.1	33	50.8	2.59
		1		7.8	3.9	3	50.0	
		2		7.5	1.3	5	17.3	
		3		13.6	7.0	15	51.5	
17	Keomah	AVERAGE	**	6.8	5.4	31	79.4	5.98
		1		2.9	2.3	6	79.3	
		2		6.6	2.1	3	31.8	
		3		4.7	0.4	3	8.5	
		4		14.3	6.4	5	44.8	
		5		6.7	4.2	7	62.7	
331	Haymond	AVERAGE		10.3	3.6	15	35.0	0.03
		1		10.6	1.6	4	15.1	
		2		10.2	4.2	10	41.2	
257	Clarksdale	AVERAGE		5.7	3.5	12	61.4	0.31
		1		6.1	4.2	7	68.9	
		2		4.7	0.9	3	19.1	
41	Muscatine	AVERAGE		5.8	1.1	4	19.0	N. A.
258	Sicily	AVERAGE		7.1	0.9	4	12.7	N. A.
16	Rushville	AVERAGE		7.4	2.1	4	28.4	N. A.

LIVINGSTON HR-510
October 13, 1987
Eqn. #2
AC > 3" thick

2.00 miles
50' interval
Air temp. 50
P.S. temp. 65

Soil #	Soil Series	Segement	Sign. Diff. at $\alpha = 0.05$(* *)	Avg. Eri	St. Dev.	# Tests	Coef. Var.	"F" Value
240	Plattville	AVERAGE		11.9	3.3	35	27.7	N. A.
232	Ashkum	AVERAGE		5.3	1.8	105	34.0	3.58
		1		5.7	1.4	61	24.6	
		2		5.1	2.8	25	54.9	
		3		4.5	1.0	19	22.2	
59	Lisbon	AVERAGE		4.1	1.4	22	34.1	N. A.
293	Andres	AVERAGE	* *	7.3	2.6	16	35.6	8.64
		1		9.7	2.0	5	20.6	
		2		6.3	2.2	11	34.9	
294	Symerton	AVERAGE		9.0	4.5	5	50.0	N. A.
69	Milford	AVERAGE		8.4	2.2	27	26.2	N. A.

MARION 23
April 28, 1987
Eqn. #2
AC > 3" thick

3.48 miles
100' intervals
Air temp. 67
P.S. temp. 104

Soil #	Soil Series	Segment	Sign. Diff. at $\alpha = 0.05$(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
991	Cisne/Huey	AVERAGE		8.6	1.7	10	19.8	N. A.
3	Hoyleton	AVERAGE	**	11.8	3.9	77	33.1	5.81
		2		10.0	0.8	7	8.0	
		3		12.6	2.0	6	15.9	
		4		12.4	4.1	12	33.1	
		5		7.6	1.9	4	25.0	
		6		12.6	5.1	14	40.5	
		7		7.7	2.5	9	32.5	
		8		14.1	2.5	23	17.7	
912	Holyeton/Darmstadt	AVERAGE		7.7	1.2	4	15.6	N. A.
2	Cisne	AVERAGE	**	8.6	3.1	83	36.0	3.69
		1		8.2	1.7	8	20.7	
		2		8.8	1.7	22	19.3	
		3		9.9	3.9	7	39.4	
		4		12.5	3.7	7	29.6	
		5		7.4	3.7	5	50.0	
		6		7.7	3.2	34	41.6	
382	Belknap	AVERAGE		11.8	1.8	4	15.3	N. A.
620	Darmstadt	AVERAGE		14.8	2.6	4	17.6	N. A.

MERCER 16
May 12, 1987
Eqn. #2
AC > 3" thick

3.66 miles
200' intervals
Air temp. 70
P.S. temp. 102

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
36	Tama	AVERAGE		3.5	1.3	13	37.1	0.04
		3		3.5	1.9	3	54.3	
		4		3.3	1.3	8	39.4	
19	Sylvan	AVERAGE		5.3	1.8	4	34.0	N. A.
274	Seaton	AVERAGE		3.3	2.6	7	78.8	N. A.
277	Port Byron	AVERAGE		3.0	1.6	9	53.3	N. A.
275	Joy	AVERAGE		2.4	1.1	69	45.8	4.24
		1		2.0	0.8	17	40.0	
		3		2.6	1.1	48	42.3	
943	Seaton/Timula	AVERAGE		1.8	0.3	8	16.7	N. A.

NEW CITY ROAD
March 26, 1986
Eqn. #3
AC surf. w/gran. base

1.75 miles
200' intervals
Air temp. 55
P.S. temp. 62

Soil #	Soil Series	Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
		Sign. Diff. at α = 0.05(* *)					
43	Ipava	AVERAGE	6.8	2.2	39	32.4	0.23
		1	6.9	2.8	10	40.6	
		2	6.7	2.1	25	31.3	
		3	7.5	0.9	4	12.0	
36	Tama	AVERAGE	8.3	2.5	13	30.1	0.05
		3	8.8	3.1	5	35.2	
		4	8.4	1.9	4	22.6	
259	Assumption	AVERAGE	10.3	2.6	4	25.2	N. A.

NEW CITY ROAD
October 4, 1985
Eqn. #3
AC surf. w/gran. base

1.75 miles
200' intervals
Air temp. 58
P.S. temp. 67

Soil #	Soil Series	Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	Sign. Diff. at $\alpha = 0.05$(**)	"F" Value
43	Ipava	AVERAGE	7.3	1.9	32	26.0	**	5.85
		1	8.4	2.2	8	26.2		
		2	6.7	1.5	22	22.4		
36	Tama	AVERAGE	8.4	2.1	12	25.0		0.03
		3	8.5	2.6	4	30.6		
		4	8.8	2.0	4	22.7		
259	Assumption	AVERAGE	10.8	2.5	4	23.1		N. A.

PEORIA 60
June 18, 1987
Eqn. #1
Surface treatment

2.52 miles
100' intervals
Air temp. 85
P.S. temp. 106

Soil #	Soil Series	Sign. Diff. at $\alpha = 0.05$(* *) Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
17	Keomah	AVERAGE	4.8	1.6	39	33.3	1.67
		1	3.0	1.3	6	43.3	
		2	4.7	1.8	5	38.3	
		3	4.6	1.6	12	34.8	
		5	4.5	1.3	3	28.9	
16	Rushville	AVERAGE	3.1	0.7	9	22.6	N. A.
279	Rozetta	AVERAGE	5.5	2.0	19	36.4	1.38
		1	5.4	2.4	4	44.4	
		2	6.2	1.5	3	24.2	
		3	6.6	1.0	4	15.2	
		4	4.2	2.3	6	54.8	
19	Sylvan	AVERAGE	5.9	1.7	9	28.8	N. A.
		1	6.0	1.9	7	31.7	
119	Elco	AVERAGE	7.7	4.8	18	62.3	N. A.
		5	9.0	5.0	13	55.6	
8	Hickory	AVERAGE	4.7	2.3	13	48.9	0.07
		1	3.9	1.8	3	46.2	
		2	4.3	3.2	5	74.4	
196	Lemond	AVERAGE	5.3	2.2	4	41.5	N. A.
280	Fayette	AVERAGE	6.6	0.6	5	9.1	N. A.
		1	6.5	0.7	4	10.8	
451	Lawson	AVERAGE	7.2	3.2	15	44.4	N. A.

PERRY 12
June 24, 1987
Eqn. #3
AC surf. w/gran. base

2.68 miles
100' intervals
Air temp. 80
P.S. temp. 88

Soil #	Soil Series	Segment	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value	Sign. Diff. at α = 0.05(**)
382	Belknap	AVERAGE	6.8	3.5	6	51.5	N. A.	
		1	4.6	0.2	4	4.3		
108	Bonnie	AVERAGE	10.8	4.3	7	39.8	N. A.	
900	Hickory/Wells	AVERAGE	7.4	3.7	20	50.0	2.11	
		1	9.6	5.2	5	54.2		
		2	9.0	2.3	4	25.6		
		3	6.8	3.2	5	47.1		
		5	4.2	1.3	4	31.0		
214	Hosmer	AVERAGE	7.6	3.7	20	48.7	0.85	
		1	5.4	3.5	4	64.8		
		2	9.8	5.2	3	53.1		
		3	7.3	0.8	5	11.0		
		4	8.1	4.4	8	54.3		
164	Stoy	AVERAGE	5.1	3.2	49	62.7	14.85	**
		1	4.2	0.9	4	21.4		
		2	5.3	1.3	12	24.5		
		3	6.2	2.8	4	45.2		
		4	3.5	1.1	22	31.4		
		5	11.7	5.7	5	48.7		
113	Oconee	AVERAGE	5.9	2.6	14	44.1	8.95	**
		1	4.1	1.8	6	43.9		
		2	7.3	2.1	8	28.8		
912	Hoyleton/Darmstadt	AVERAGE	6.9	2.6	14	37.7	2.03	
		1	8.5	2.2	4	25.9		
		2	7.3	1.6	3	21.9		
		3	5.0	2.9	3	58.0		
916	Darmstadt/Oconee	AVERAGE	3.2	1.7	6	53.1	N. A.	

PERRY 21
August 26, 1987
Eqr. #1
Surface treatment

4.37 miles
100' intervals
Air temp. 77
P.S. temp. 83

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
164	Stoy	AVERAGE	* *	7.6	2.6	88	34.2	4.45
		1		9.6	3.8	6	39.6	
		2		9.1	1.2	9	13.2	
		3		8.3	2.0	31	24.1	
		5		5.6	2.1	7	37.5	
		7		8.3	1.6	3	19.3	
		8		5.2	2.8	10	53.8	
		9		7.9	2.5	9	31.6	
		11		6.3	2.1	8	33.3	
5	Blair	AVERAGE		6.7	2.4	61	35.8	1.46
		4		6.5	1.8	8	27.7	
		6		5.6	2.0	5	35.7	
		8		5.2	2.1	11	40.4	
		9		7.3	2.9	14	39.7	
		10		7.0	2.2	4	31.4	
		11		7.7	1.5	8	19.5	
		12		6.6	2.0	3	30.3	
214	Hosmer	AVERAGE		7.5	3.0	58	40.0	1.79
		1		7.7	2.2	9	28.6	
		2		8.1	2.3	18	28.4	
		4		9.2	3.9	3	42.4	
		5		7.2	4.1	4	56.9	
		10		5.8	2.9	13	50.0	
165	Weir	AVERAGE		7.0	2.3	24	32.9	N. A.

PERRY 154
June 24, 1987
Eqn. #2
AC > 3" thick

3.15 miles
100' intervals
Air temp. 90
P.S. temp. 110

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
3	Hoyleton	AVERAGE	**	6.1	1.9	47	31.1	3.78
		1		6.0	1.6	7	26.7	
		2		4.2	0.6	3	14.3	
		5		6.3	1.9	20	30.2	
		6		4.5	1.4	7	31.1	
		9		8.2	2.2	4	26.8	
2	Cisne	AVERAGE		6.8	2.5	11	36.8	0.49
		1		6.3	3.3	3	52.4	
		2		6.6	2.7	3	40.9	
		4		8.5	2.8	3	32.9	
912	Hoyleton/Darmstadt	AVERAGE	**	5.9	2.0	10	33.9	9.12
		1		4.1	1.5	4	36.6	
		2		7.0	1.2	4	17.1	
929	Ava/Hickory	AVERAGE		6.6	1.8	7	27.3	N. A.
		1		5.6	2.2	3	39.3	
108	Bonnie	AVERAGE		5.7	2.6	6	45.6	N. A.
14	Ava	AVERAGE		7.9	1.3	4	16.5	N. A.
5	Blair	AVERAGE		7.5	2.5	47	33.3	1.85
		1		7.2	1.1	4	15.3	
		2		7.2	4.3	5	59.7	
		3		6.9	1.6	5	23.2	
		4		7.7	2.3	7	29.9	
		6		7.8	1.4	3	17.9	
		7		7.8	1.8	3	23.1	
		8		9.2	2.9	10	31.5	
		9		5.7	2.0	8	35.1	

PERRY 154
June 24, 1987
Eqn. #2
AC > 3" thick

3.15 miles
100' intervals
Air temp. 90
P.S. temp. 110

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
13	Bluford	AVERAGE	* *	7.4	2.1	59	28.4	8.46
		1		6.9	1.9	17	27.5	
		2		6.1	1.2	13	19.7	
		3		4.7	0.5	3	10.6	
		4		8.4	1.5	7	17.9	
		5		8.8	1.8	19	20.5	
8	Hickory	AVERAGE		8.1	2.0	4	24.7	N. A.
12	Wynoose	AVERAGE		6.6	1.7	7	25.8	N. A.
382	Belknap	AVERAGE		6.7	1.2	14	17.9	5.64
		1		8.0	1.0	4	12.5	
		2		6.8	0.8	10	11.8	

B-16

PIATT 5
March 31, 1987
Eqn. #1
Surface treatment

3.62 miles
125' intervals
Air temp. 37
P.S. temp. 60

Soil #	Soil Series	Segment	Sign. Diff. at $\alpha = 0.05$(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
330	Peotone	AVERAGE		7.3	2.5	4	34.2	N. A.
43	Ipava	AVERAGE	**	5.3	2.4	27	45.3	16.72
		1		6.8	2.5	13	36.8	
		2		3.8	1.1	14	28.9	
68	Sable	AVERAGE		7.2	3.0	19	41.7	N. A.
		9		6.4	1.8	3	28.1	
154	Flanagan	AVERAGE	**	7.8	2.2	42	28.2	3.20
		1		7.9	1.7	4	21.5	
		2		8.6	0.4	4	4.7	
		3		4.7	1.8	6	38.3	
		4		8.9	0.9	4	10.1	
		5		8.0	2.2	3	27.5	
		6		7.8	1.4	5	17.9	
		7		8.7	2.5	13	28.7	
		8		6.6	0.7	3	10.6	
291	Xenia	AVERAGE		7.0	1.3	14	18.6	0.01
		1		7.1	1.9	4	26.8	
		2		7.1	1.2	5	16.9	
		3		7.0	1.2	4	17.1	
322	Russell	AVERAGE		7.8	3.3	11	42.3	0.08
		1		8.2	2.3	4	28.0	
		2		7.6	3.9	7	51.3	
171	Catlin	AVERAGE		6.8	1.7	15	25.0	1.09
		1		7.9	1.5	3	19.0	
		2		6.0	2.0	4	33.3	
		3		6.7	1.6	8	23.9	
27	Miami	AVERAGE		4.3	2.4	12	55.8	N. A.

WILLIAMSON 3
April 17, 1987
Eqn. #1
Surface treatment

2.35 miles
100' intervals
Air temp. 55
P.S. temp. 58

Soil #	Soil Series	Segment	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
14	Ava	AVERAGE		9.0	2.3	73	25.6	0.55
		2		8.9	2.9	19	32.6	
		3		8.6	2.2	17	25.6	
		4		9.5	2.0	6	21.1	
		6		9.4	2.0	9	21.3	
		7		9.4	1.3	13	13.8	
		8		10.3	1.4	4	13.6	
814	Hickory/Ava	AVERAGE		9.2	2.4	16	26.1	0.01
		1		8.5	1.9	5	22.4	
		5		8.6	1.9	7	22.1	
382	Belknap	AVERAGE		8.0	1.7	23	21.3	2.02
		1		6.8	1.1	5	16.2	
		2		9.5	2.5	4	26.3	
		3		8.0	1.0	5	12.5	
		4		9.0	1.7	9	18.9	
13	Bluford	AVERAGE		7.3	1.6	14	21.9	4.16
		1		6.8	1.3	8	19.1	
		2		8.4	1.5	5	17.9	

APPENDIX C

PROJECT-PROJECT ANALYSES

(Individual Soil Series Segment Approach)

Appendix C presents the average E_{Ri} values for those soil series occurring in <u>more than one</u> project. The average E_{Ri} value for a given soil series is based on individual segments of that soil series. The standard deviation and coefficient of variation for each soil series are also included. Similar soil series segments are grouped together to show the data that were used to get the overall averages. The high and low E_{Ri} values are also indicated.

An "F-value" is also shown. Significant differences at $\alpha = 0.05$ are indicated.

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at $\alpha = 0.05$(*)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
14	Ava	AVERAGE		8.6	1.3		15.1	1.63
		Bond Co.		8.5	2.5	11	29.4	
				8.5	3.2	13	37.6	
				7.0	2.2	6	31.4	
				6.6	1.1	5	16.7	
				8.7	4.2	17	48.3	
				9.7	3.8	17	39.2	
				Low 5.8	3.9	9	67.2	
		Il 15		High 10.4	3.2	13	30.8	
		Perry Co. 154		7.9	1.3	4	16.5	
		Williamson Co.		8.9	2.9	19	32.6	
				8.6	2.2	17	25.6	
				9.5	2.0	6	21.1	
				9.4	2.0	9	21.3	
				9.4	1.3	13	13.8	
				10.3	1.4	4	13.5	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
382	Belknap	AVERAGE	**	8.6	2.6	20	30.2	5.05
		Il 15		9.0	2.8	7	31.1	
				8.7	3.7	3	42.5	
				High 15.3	2.1	3	13.7	
				7.2	2.5	3	34.7	
				7.6	3.4	3	44.7	
		Marion Co.		11.8	1.8	4	15.3	
		Perry Co. 12		Low 4.6	0.2	4	4.3	
		Perry Co. 154		8.0	1.0	4	12.5	
				6.8	0.8	10	11.8	
		Williamson Co.		6.8	1.1	5	16.2	
				9.5	2.5	4	26.3	
				8.0	1.0	5	12.5	
				8.0	1.7	9	21.3	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
5	Blair	AVERAGE		7.0	1.1	5	15.7	1.73
		Il 15		Low 4.8	2.7	5	56.3	
		Perry Co. 21		6.5	1.8	8	27.7	
				5.6	2.0	5	35.7	
				5.2	2.1	11	40.4	
				7.3	2.9	14	39.7	
				7.0	2.2	4	31.4	
				7.7	1.5	8	19.5	
				7.6	2.0	3	26.3	
		Perry Co. 154		7.2	1.1	4	15.3	
				7.2	4.3	5	59.7	
				6.9	1.6	5	23.2	
				7.7	2.3	7	29.9	
				7.8	1.4	3	17.9	
				7.8	1.8	3	23.1	
				High 9.2	2.9	10	31.5	
				5.7	2.0	8	35.1	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
13	Bluford	AVERAGE	* *	7.5	2.0		26.7	2.29
		Bond Co.		6.2	3.9	4	62.9	
				6.9	3.1	21	44.9	
				8.9	4.3	8	48.3	
				8.2	4.0	26	48.8	
				4.8	6.2	3	129.2	
				High 13.6	1.9	3	14.0	
		Il 15		6.8	2.2	13	32.4	
				6.8	2.2	7	32.4	
				7.9	2.4	12	30.4	
				7.5	3.7	7	49.3	
		Williamson Co.		6.8	1.3	8	19.1	
				8.4	1.5	5	17.9	
		Perry Co. 154		6.9	1.9	17	27.5	
				6.1	1.2	13	19.7	
				Low 4.7	0.5	3	10.6	
				8.4	1.5	7	17.9	
				8.8	1.8	19	20.5	
108	Bonnie	AVERAGE		8.7	3.0		34.5	5.68
		Perry Co. 12		High 10.8	4.3	7	39.8	
		Perry Co. 154		Low 6.6	1.8	7	27.3	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (Ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
2	Cisne	AVERAGE	* *	7.9	2.1		26.6	11.89
		Bond Co.		Low 4.5	1.9	56	42.2	
				6.2	1.8	15	29.0	
		Marion Co.		8.2	1.7	8	20.7	
				8.8	1.7	22	19.3	
				9.9	3.9	7	39.4	
				High 12.5	3.7	7	29.6	
				7.4	3.7	5	50.0	
				7.7	3.2	34	41.6	
		Perry Co. 154		6.3	3.3	3	52.4	
				6.6	2.7	3	40.9	
				8.5	2.8	3	32.9	
257	Clarksdale	AVERAGE		6.3	1.7		27.0	0.73
		Jersey Co. 9		High 8.0	1.6	3	20.0	
		Jersey Co. 25		6.1	4.2	7	68.9	
				Low 4.7	0.9	3	19.1	
18	Clinton	AVERAGE	* *	8.2	4.1		50.0	9.11
		Jersey Co. 9		Low 3.7	1.8	12	48.6	
		Jersey Co. 25		7.8	3.9	3	50.0	
				7.5	1.3	5	17.3	
				High 13.6	7.0	15	51.5	
331	Haymond	AVERAGE		9.5	1.5		15.8	0.97
		Jersey Co. 9		Low 7.8	2.7	5	34.6	
		Jersey Co. 25		High 10.6	1.6	4	15.1	
				10.2	4.2	10	41.8	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
8	Hickory	AVERAGE	* *	9.5	3.2		33.7	2.15
		Bond Co.		11.2	6.9	11	61.6	
				14.4	8.2	4	56.9	
		Jersey Co. 9		6.5	6.6	4	101.5	
				10.2	6.5	12	63.7	
				9.1	0.5	4	5.5	
		Jersey Co. 25		8.3	3.2	3	38.6	
				8.7	3.9	4	44.8	
				High 14.9	6.6	12	44.3	
				12.9	5.0	6	38.8	
				11.7	5.3	15	45.3	
				11.1	3.8	9	34.2	
		Peoria Co.		Low 3.9	1.8	3	46.2	
				4.3	3.2	5	74.4	
		Perry Co. 154		8.1	2.0	4	24.7	
		Williamson Co.		8.5	1.9	5	22.4	
				8.6	1.9	7	22.1	
214	Hosmer	AVERAGE		7.6	1.4		18.4	1.21
		Perry Co. 12		Low 5.4	3.5	4	64.8	
				High 9.8	5.2	3	53.1	
				7.3	0.8	5	11.0	
				8.1	4.4	8	54.3	
		Perry Co. 21		7.7	2.2	9	28.6	
				8.1	2.3	18	28.4	
				9.2	3.9	3	42.4	
				7.2	4.1	4	56.9	
				5.8	2.9	13	50.0	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
3	Hoyleton	AVERAGE	* *	8.3	3.1		37.3	12.42
		Bond Co.		5.6	3.1	15	55.4	
				4.8	1.6	10	33.3	
				7.2	4.2	16	58.3	
				8.9	3.8	19	42.7	
		Il 15		7.7	2.0	9	26.0	
		Marion Co.		10.0	0.8	7	8.0	
				12.6	2.0	6	15.9	
				12.4	4.1	12	33.1	
				7.6	1.9	4	25.0	
				12.6	5.1	14	40.5	
				7.7	2.5	9	32.5	
		Perry Co. 154		High 14.1	2.5	23	17.7	
				6.0	1.6	7	26.7	
				Low 4.2	0.6	3	14.3	
				6.3	1.9	20	30.2	
				4.5	1.4	7	31.1	
				8.2	2.2	4	26.8	
912	Hoyle/Darms	AVERAGE		6.6	1.7		25.8	3.33
		Marion Co.		7.7	1.2	4	15.6	
		Perry Co. 12		High 8.5	2.2	4	25.9	
				7.3	1.6	3	21.9	
				5.0	2.9	3	58.0	
		Perry Co. 154		Low 4.1	1.5	4	36.6	
				7.0	1.2	4	17.1	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
43	Ipava	AVERAGE	**	6.7	1.4		20.9	5.90
		Piatt Co.		6.8	2.5	13	36.8	
				Low 3.8	1.1	14	28.9	
		New City M86		6.9	2.8	10	40.6	
				6.7	2.1	25	31.3	
				7.5	0.9	4	12.0	
		New City O85		High 8.4	2.2	8	26.2	
				6.7	1.5	22	22.4	
17	Keomah	AVERAGE	**	5.8	3.5		60.3	7.10
		Jersey Co. 25		Low 2.9	2.3	6	79.3	
				6.6	2.1	3	31.8	
				4.7	0.4	3	8.5	
				High 14.3	6.4	5	44.8	
				6.7	4.2	7	62.7	
		Peoria Co.		3.0	1.3	6	43.3	
				4.7	1.8	5	38.3	
				4.6	1.6	12	34.8	
				4.5	1.3	3	28.9	
41	Muscatine	AVERAGE		5.4	0.5		9.3	0.38
		Jersey Co. 9		Low 5.1	2.0	4	39.2	
		Jersey Co. 25		High 5.8	1.1	4	19.0	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at $\alpha = 0.05$(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
279	Rozetta	AVERAGE		6.7	1.5		22.4	2.01
		Jersey Co. 9		High 9.3	3.7	8	39.8	
				6.7	3.2	15	47.8	
				8.5	2.6	14	30.6	
				6.8	2.7	57	39.7	
				6.8	3.7	20	54.4	
		Peoria Co.		5.4	2.4	4	44.4	
				6.2	1.5	3	24.2	
				6.6	1.0	4	15.2	
				Low 4.2	2.3	6	54.8	
16	Rushville	AVERAGE	* *	5.2	3.0		57.7	32.84
		Jersey Co. 25		High 7.4	2.1	4	28.4	
		Peoria Co.		Low 3.1	0.7	9	22.6	
258	Sicily	AVERAGE		7.5	0.8		10.7	1.58
		Jersey Co. 9		Low 6.9	2.3	16	33.3	
				High 8.4	1.5	8	17.9	
		Jersey Co. 25		7.1	0.9	4	12.7	

INDIVIDUAL SOIL SERIES SEGMENT DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
164	Stoy	AVERAGE	**	7.0	2.4		34.3	10.54
		Perry Co. 12		4.2	0.9	4	21.4	
				5.3	1.3	12	24.5	
				6.2	2.8	4	45.2	
				Low 3.5	1.1	22	31.4	
				High 11.7	5.7	5	48.7	
		Perry Co. 21		9.6	3.8	6	39.6	
				9.1	1.2	9	13.2	
				8.3	2.0	31	24.1	
				5.6	2.1	7	37.5	
				8.3	1.6	3	19.3	
				5.2	2.8	10	53.8	
				7.9	2.5	9	31.6	
				6.3	2.1	8	33.3	
19	Sylvan	AVERAGE		5.6	0.5		8.9	0.36
		Mercer Co.		Low 5.3	1.8	4	34.0	
		Peoria Co.		High 6.0	1.9	7	31.7	
36	Tama	AVERAGE	**	6.9	2.7		39.1	8.17
		Mercer Co.		Low 3.5	1.9	3	54.3	
				3.3	1.3	8	39.4	
		New City M86		High 8.8	3.1	5	35.2	
				8.4	1.9	4	22.6	
		New City O85		8.5	2.6	4	30.6	
				High 8.8	2.0	4	22.7	

APPENDIX D

PROJECT-PROJECT ANALYSES

(Project-Wide Average Approach)

Appendix D presents average E_{Ri} values for all of the soil series occurring in more than one project. The average E_{Ri} value for a given soil series is based on the project-wide averages from the individual projects. The standard deviation, coefficient of variation and number of samples are also included.

An "F-value" is also given. Significant differences at $\alpha = 0.05$ are also indicated.

PROJECT-WIDE AVERAGE DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
14	Ava	AVERAGE		8.9	1.1		12.4	1.89
		Bond Co.		8.4	3.6	81	42.9	
		Il 15		10.4	3.2	13	30.8	
		Perry Co.154		7.9	1.3	4	16.5	
		Williamson Co.		9.0	2.3	73	25.6	
382	Belknap	AVERAGE	* *	8.4	2.1		25.0	3.84
		Il 15		8.9	3.4	44	38.2	
		Marion Co.		11.8	1.8	4	15.3	
		Perry Co. 12		6.8	3.5	6	51.5	
		Perry Co. 154		6.7	1.2	14	17.9	
		Williamson Co.		8.0	1.7	23	21.3	
5	Blair	AVERAGE		6.3	1.4		22.2	3.42
		Il 15		4.8	2.7	5	56.3	
		Perry Co. 21		6.7	2.4	61	35.8	
		Perry Co. 154		7.5	2.5	47	33.3	
13	Bluford	AVERAGE		7.4	0.3		4.1	0.55
		Bond Co.		7.9	4.0	65	50.6	
		Il 15		7.2	2.5	39	34.7	
		Williamson Co.		7.3	1.6	14	21.9	
		Perry Co. 154		7.4	2.1	59	28.4	
108	Bonnie	AVERAGE		8.7	3.0		34.5	5.68
		Perry Co. 12		10.8	4.3	7	39.8	
		Perry Co. 154		6.6	1.8	7	27.3	
2	Cisne	AVERAGE	* *	6.8	1.9		27.9	37.54
		Bond Co.		4.9	2.0	71	40.8	
		Marion Co.		8.6	3.1	83	36.0	
		Perry Co. 154		6.8	2.5	11	36.8	
257	Clarksdale	AVERAGE		6.8	1.6		23.5	1.18
		Jersey Co. 9		8.0	1.0	3	12.5	
		Jersey Co. 25		5.7	3.5	12	61.4	

PROJECT-WIDE AVERAGE DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05(* *)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
18	Clinton	AVERAGE	* *	7.8	5.9		75.6	21.86
		Jersey Co. 9		3.7	1.8	12	48.6	
		Jersey Co. 25		12.0	6.1	33	50.8	
331	Haymond	AVERAGE		9.0	1.8		20.0	2.00
		Jersey Co. 9		7.8	2.7	5	34.6	
		Jersey Co. 25		10.3	3.6	15	35.0	
8	Hickory	AVERAGE	* *	9.2	2.8		30.4	5.47
		Bond Co.		12.1	7.1	15	58.7	
		Jersey Co. 9		9.2	5.2	20	56.5	
		Jersey Co. 25		12.1	5.4	52	44.6	
		Peoria Co.		4.7	2.3	13	48.9	
		Perry Co. 154		8.1	2.0	4	24.7	
		Williamson Co..		9.2	2.4	16	26.1	
214	Hosmer	AVERAGE		7.6	0.1		1.3	0.01
		Perry Co. 12		7.6	3.7	20	48.7	
		Perry Co. 21		7.5	3.0	58	40.0	
3	Hoyleton	AVERAGE	* *	8.1	2.5		30.9	36.86
		Bond Co.		6.9	3.7	62	53.6	
		Il 15		7.7	2.0	9	26.0	
		Marion Co.		11.8	3.9	77	33.1	
		Perry Co. 154		6.1	1.9	47	31.1	
912	Hoyle/Darms	AVERAGE		6.8	0.9		13.2	1.06
		Marion Co.		7.7	1.2	4	15.6	
		Perry Co. 12		6.9	2.6	14	37.7	
		Perry Co. 154		5.9	2.0	10	33.9	
43	Ipava	AVERAGE	* *	6.5	1.0		15.4	6.68
		Piatt Co.		5.3	2.4	27	45.3	
		New City M86		7.3	1.9	32	26.0	
		New City O85		6.8	2.2	39	32.4	

PROJECT–WIDE AVERAGE DATA

Soil #	Soil Series	Project	Sign. Diff. at α = 0.05 (**)	Avg. Eri (ksi)	St. Dev.	# Tests	Coef. Var.	"F" Value
17	Keomah	AVERAGE	**	5.8	1.4		24.1	4.83
		Jersey Co. 25		6.8	5.4	31	79.4	
		Peoria Co.		4.8	1.6	39	33.3	
41	Muscatine	AVERAGE		5.4	0.5		9.3	0.38
		Jersey Co. 9		5.1	2.0	4	39.2	
		Jersey Co. 25		5.8	1.1	4	19.0	
279	Rozetta	AVERAGE	**	6.4	1.2		18.8	5.32
		Jersey Co. 9		7.2	3.1	114	43.1	
		Peoria Co.		5.5	2.0	19	36.4	
16	Rushville	AVERAGE	**	5.2	3.0		57.7	32.84
		Jersey Co. 25		7.4	2.1	4	28.4	
		Peoria Co.		3.1	0.7	8	22.6	
258	Sicily	AVERAGE		7.2	0.2		2.8	0.07
		Jersey Co. 9		7.4	2.2	24	29.7	
		Jersey Co. 25		7.1	0.9	4	12.7	
164	Stoy	AVERAGE	**	6.4	1.8		28.1	24.60
		Perry Co. 12		5.1	3.2	49	62.7	
		Perry Co. 21		7.6	2.6	88	34.2	
19	Sylvan	AVERAGE		5.6	0.4		7.1	0.33
		Mercer Co.		5.3	1.8	4	34.0	
		Peoria Co.		5.9	1.7	9	28.8	
36	Tama	AVERAGE	**	6.7	2.8		41.8	24.47
		Mercer Co.		3.5	1.3	13	37.1	
		New City M86		8.3	2.5	13	30.1	
		New City O85		8.4	2.1	12	25.0	

APPENDIX E

LSD (LEAST SIGNIFICANT DIFFERENCE) COMPARISONS

Appendix E presents the results of the LSD tests conducted on the soil series which had a significant difference at $\alpha = 0.05$ with the "F-tests". The LSD tests identify those ranges within the data that are not statistically significantly different $\alpha = 0.05$. These ranges are underlined.

Note: All E_{Ri} data are ksi.

WITHIN PROJECT COMPARISONS
(All Values are in ksi)

Bond Co.	Il 15	Marion Co.
Hoyleton	Belknap	Cisne

4.8	7.2	7.4
5.6	7.6	7.7
7.2	8.7	8.2
8.9	9.0	8.8
Range = 4.1 ksi	15.3	9.9
	Range = 8.1 ksi	12.5
		Range = 5.1 ksi

Perry 12	Perry 21	Perry 21
Stoy	Stoy	Hoyleton

3.5	5.2	4.2
4.2	5.6	4.5
5.3	6.3	6.0
6.2	7.9	6.3
11.7	8.3	8.2
Range = 8.2 ksi	8.3	Range = 4.0 ksi
	9.1	
	9.6	
	Range = 4.4 ksi	

Piatt Co.
Flanagan

4.7
6.6
7.8
7.9
8.0
8.6
8.7
8.9

Range = 4.2 ksi

Jersey 25
Keomah

2.9
4.7
6.6
6.7
14.3

Range = 11.4 ksi

Perry 154
Bluford

4.7
6.1
6.9
8.4
8.8

Range = 4.1 ksi

Marion Co.
Hoyleton

7.6
7.7
10.0
12.4
12.6
12.6
.14.1

Range = 6.5 ksi

PROJECT – PROJECT COMPARISONS
(Project–wide Average Approach)
(All Values are in ksi)

Hoyleton

6.1 d |
6.9 a |
7.7 b |
11.8 c

Range = 5.7 ksi

a – Bond Co.
b – Il 15
c – Marion Co.
d – Perry 154

Cisne

4.9 a
6.8 c
8.6 b

Range = 3.7 ksi

a – Bond Co.
b – Marion Co.
c – Perry 154

Hickory

4.7 d
8.1 e |
9.2 b |
9.2 f |
12.1 a |
12.1 c |

Range = 7.4 ksi

a – Bond Co.
b – Jersey 9
c – Jersey 25
d – Peoria Co.
e – Perry 154
f – Williamson Co.

Ipava

5.3 a
6.8 b |
7.3 c |

Range = 2.0 ksi

a – Piatt Co.
b – New City, M86
c – New City ,O87

Belknap

6.7 d |
6.8 c |
8.0 e |
8.9 a | |
11.8 b |

Range = 5.1 ksi

a – Il 15
b – Marion Co.
c – Perry 12
d – Perry 154
e – Williamson Co.

Tama

3.5 a
8.3 b |
8.4 c |

Range = 4.9 ksi

a – Mercer Co.
b – New City, M86
c – New City, O87

PROJECT – PROJECT COMPARISONS
(Soil Series Segment Approach)
(All Values are in ksi)

Hoyleton		Cisne		Bluford	
4.2	d	4.5	a	4.7	d
4.5	d	6.2	a	4.8	a
4.8	a	6.3	c	6.1	d
5.6	a	6.6	c	6.2	a
6.0	d	7.4	b	6.8	b
6.3	d	7.7	b	6.8	b
7.2	a	8.2	b	6.8	c
7.6	c	8.5	c	6.9	a
7.7	c	8.8	b	6.9	d
7.7	b	9.9	b	7.5	b
8.2	d	12.5	b	7.9	b
8.9	a			8.2	a
10.0	c			8.4	c
12.4	c			8.4	d
12.6	c			8.8	d
12.6	c			8.9	a
14.1	c			13.6	a

Cisne

Range = 8.0 ksi

a–Bond Co.
b–Marion Co.
c–Perry 154

Hoyleton

Range = 9.9 ksi

a–Bond Co.
b–Il 15
c–Marion Co.
d–Perry 154

Bluford

Range = 8.9 ksi

a–Bond Co.
b–Il 15
c–Williamson
d–Perry 154

Hickory			Belknap			Clinton		
3.9	d		4.6	c		3.7	a	
4.3	d		6.8	d		7.5	b	
6.5	b		6.8	e		7.8	b	
8.1	e		7.2	a		13.6	b	
8.3	c		7.6	a				
8.5	f		8.0	e		Range = 9.9 ksi		
8.6	f		8.0	e				
8.7	c		8.0	d		a–Jersey 9		
9.1	b		8.7	a		b–Jersey 25		
10.2	b		9.0	a				
11.1	c		9.5	e				
11.2	a		11.8	b				
11.7	c		15.3	a				
12.9	c							
14.4	a		Range = 8.7 ksi					
14.9	c							

Range = 11.0 ksi

a–Bond Co.
b–Jersey 9
c–Jersey 25
d–Peoria Co.
e–Perry 154
f–Williamsom Co.

a–Il 15
b–Marion Co.
c–Perry 12
d–Perry 154
e–Williamson Co.

Keomah

2.9 a

3.0 b

4.5 b

4.6 b

4.7 b

4.7 a

6.6 a

6.7 a

14.3 a

Range = 11.4 ksi

a–Jersey 25
b–Peoria Co.

Ipava

3.8 a

6.7 b

6.7 c

6.8 a

6.9 b

7.5 b

8.4 c

Range = 4.6 ksi

a–Piatt Co.
b–New City,M86
c–New City,O85

Stoy

3.5 a

4.2 a

5.2 b

5.3 a

5.6 b

6.2 a

6.3 b

7.9 b

8.3 b

8.3 b

9.1 b

9.6 b

11.7 a

Range = 8.2 ksi

a–Perry 12
b–Perry 21

Tama

3.3 a

3.5 a

8.4 b

8.5 c

8.8 c

8.8 b

Range = 5.5 ksi

a–Mercer Co.
b–New City,M
c–New City,O

APPENDIX F

AVERAGE E_{Ri} VS PERCENTILE DISTRIBUTION

This Appendix summarizes average E_{Ri} values and percentile distribution values for the various soil series encountered in each project. Ratios of 85%/50% and 100%/50% are presented and average ratios for the various projects are shown.

PROJECT(soil series)	AVG. Eri (ksi)	50%ILE (ksi)	85%ILE (ksi)	100%ILE (ksi)	85%/50%	100%/50%
Bond(Atlas)	8.3	6.7	1.5	1.1	.22	.16
Bond(Ava)	8.4	7.7	5.0	1.4	.65	.18
Bond(Bluford)	7.9	7.0	3.8	0.9	.54	.13
Bond(Cisne)	4.9	4.7	2.9	0.9	.62	.19
Bond(Hoyleton)	6.9	5.8	3.2	1.5	.55	.26
Bond(Hickory)	12.1	11.2	5.3	1.6	.47	.14
				Average	.51	.18
				St. Dev.	.15	.05
I115(Ava)	10.4	10.3	6.9	3.4	.67	.33
I115(Bluford)	7.2	7.4	4.2	2.2	.57	.30
I115(Robbs)	6.6	6.5	3.8	2.2	.58	.34
I115(Zanesville)	10.4	10.5	7.9	1.2	.75	.11
I115(Belknap)	8.9	8.9	5.1	1.1	.57	.12
I115(Coffeen)	8.6	8.5	7.0	6.8	.82	.80
I115(Hoyleton)	7.7	7.5	6.0	4.5	.80	.60
I115(Grantsburg)	9.7	9.5	7.1	4.2	.75	.44
I115(Blair)	4.8	4.2	2.4	2.0	.57	.48
				Average	.68	.39
				St. Dev.	.11	.22
Jersey25(Keomah)	6.8	5.9	2.2	0.9	.37	.15
Jersey25(Muscatine)	5.8	6.3	4.7	4.6	.75	.73
Jersey25(Clarksdale)	5.7	5.0	2.9	2.0	.58	.40
Jersey25(Haymond)	10.3	10.8	6.2	5.0	.57	.46
Jersey25(Sicily)	7.1	7.5	6.2	6.1	.83	.81
Jersey25(Rushville)	7.4	7.9	4.8	4.6	.61	.58
Jersey25(Clinton)	12.0	10.8	5.5	2.2	.51	.20
Jersey25(Hickory)	12.1	12.0	5.5	2.9	.46	.24
				Average	.58	.45
				St. Dev.	.15	.25

PROJECT(soil series)	AVG. Eri (ksi)	50%ILE (ksi)	85%ILE (ksi)	100%ILE (ksi)		85%/50%	100%/50%
Jersey9(Rozetta)	7.2	7.3	3.8	1.6		.52	.22
Jersey9(Hickory)	9.2	8.0	5.4	3.3		.68	.41
Jersey9(Muscatine)	5.1	5.2	2.9	2.6		.56	.50
Jersey9(Clarksdale)	8.0	8.3	6.4	6.2		.77	.75
Jersey9(Camden)	8.0	8.2	6.3	6.1		.77	.74
Jersey9(Wakeland)	8.3	8.4	5.5	4.9		.65	.58
Jersey9(Haymond)	7.8	6.5	5.9	5.4		.91	.83
Jersey9(Clinton)	3.7	2.8	2.2	1.7		.79	.61
Jersey9(Sicily)	7.4	7.3	5.2	2.7		.71	.37
Jersey9(Stronghurst)	8.1	6.8	5.8	4.7		.85	.69
					Average	.72	.57
					St. Dev.	.12	.19
Livingston(Milford)	8.4	8.1	6.6	3.6		.81	.44
Livingston(Lisbon)	4.1	3.8	2.7	2.2		.71	.58
Livingston(Symerton)	9.0	9.0	4.1	3.4		.46	.38
Livingston(Andres)	7.3	6.9	4.9	3.4		.71	.49
Livingston(Plattville)	11.9	12.4	8.2	4.4		.66	.35
Livingston(Ashkum)	5.3	5.4	3.4	2.1		.63	.39
					Average	.66	.44
					St. Dev.	.12	.08
Marion(Cisne/Huey)	8.6	9.2	7.1	4.5		.77	.49
Marion(Cisne)	8.6	8.7	5.6	1.6		.64	.18
Marion(Darmstadt)	14.8	13.8	13.4	13.2		.97	.96
Marion(Hoyleton)	11.8	11.5	8.0	2.5		.70	.22
Marion(Belknap)	11.8	11.8	9.9	9.6		.84	.81
Marion(Hoyl/Darm)	7.7	8.2	6.2	6.0		.76	.73
					Average	.78	.57
					St. Dev.	.12	.32

F-3

PROJECT(soil series)	AVG. Eri (ksi)	50%ILE (ksi)	85%ILE (ksi)	100%ILE (ksi)	85%/50%	100%/50%
Mercer(Port Byron)	3.0	2.5	1.6	1.5	.64	.60
Mercer(Sylvan)	5.3	5.1	3.6	3.4	.71	.67
Mercer(Seaton/Timula)	1.8	1.9	1.6	1.2	.84	.63
Mercer(Joy)	2.4	1.9	1.4	1.2	.74	.63
Mercer(Tama)	3.5	3.8	2.0	1.8	.53	.47
Mercer(Seaton)	3.3	3.0	1.7	1.3	.57	.43
Average					.67	.57
St. Dev.					.12	.10
Peoria(Elco)	7.7	7.2	3.3	2.4	.46	.33
Peoria(Sylvan)	5.9	5.7	4.5	3.9	.79	.68
Peoria(Rushville)	3.1	3.2	2.1	2.0	.66	.63
Peoria(Hickory)	4.7	5.2	1.9	0.9	.37	.17
Peoria(Lawson)	7.2	6.5	4.3	3.0	.66	.46
Peoria(Lemond)	5.3	4.9	3.4	3.1	.69	.63
Peoria(Rozetta)	5.5	5.7	3.1	1.2	.54	.21
Peoria(Keomah)	4.8	5.0	2.8	1.8	.56	.36
Peoria(Fayette)	6.6	6.7	5.8	5.7	.87	.85
Average					.62	.48
St. Dev.					.16	.23
Perry12(Stoy)	5.1	4.5	2.7	1.7	.60	.38
Perry12(Belknap)	6.8	4.9	4.5	4.3	.92	.88
Perry12(Hoyl/Darm)	6.9	7.1	3.9	2.1	.55	.30
Perry12(Darm/Ocon)	3.2	2.5	1.8	1.6	.72	.64
Perry12(Oconee)	5.9	6.6	3.1	1.2	.47	.18
Perry12(Bonnie)	10.8	12.7	5.9	5.4	.46	.43
Perry12(Hosmer)	7.6	7.4	3.2	2.0	.43	.27
Perry12(Hick/Wells)	7.4	6.9	3.5	1.5	.51	.22
Average					.58	.41
St. Dev.					.16	.24

PROJECT(soil series)	AVG. Eri (ksi)	50%ILE (ksi)	85%ILE (ksi)	100%ILE (ksi)	85%/50%	100%/50%
Perry154(Hickory)	8.1	8.3	6.2	6.0	.75	.72
Perry154(Wynoose)	6.6	6.7	4.7	4.5	.70	.67
Perry154(Hoyleton)	6.1	5.8	4.1	2.8	.71	.48
Perry154(Bluford)	7.4	7.5	5.0	3.6	.67	.48
Perry154(Belknap)	6.7	7.1	5.9	4.5	.83	.63
Perry154(Cisne)	6.8	5.7	4.6	3.4	.81	.60
Perry154(Ava/Hick)	6.6	6.8	4.4	4.1	.65	.60
Perry154(Blair)	7.5	7.1	5.2	3.1	.73	.44
Perry154(Bonnie)	5.7	4.6	4.0	3.4	.87	.74
Perry154(Ava)	7.9	7.8	6.8	6.6	.87	.85
Perry154(Hoyl/Darm)	5.9	6.0	3.2	2.8	.53	.47
				Average	.74	.61
				St. Dev.	.10	.13
Perry21(Blair)	6.7	6.5	3.8	2.4	.58	.37
Perry21(Hosmer)	7.5	7.5	4.4	1.3	.59	.17
Perry21(Stoy)	7.6	7.7	4.7	1.2	.61	.16
Perry21(Weir)	7.0	6.6	4.6	3.3	.70	.50
				Average	.62	.30
				St. Dev.	.05	.16
Piatt(Ipava)	5.3	5.1	2.6	1.9	.51	.37
Piatt(Miami)	4.3	5.1	1.5	0.9	.29	.18
Piatt(Russell)	7.8	8.0	6.0	2.2	.75	.28
Piatt(Flanagan)	7.8	8.3	3.2	1.4	.39	.17
Piatt(Peotone)	7.3	7.5	4.6	4.2	.61	.56
Piatt(Catlin)	6.8	6.6	5.1	3.4	.77	.52
Piatt(Xenia)	7.0	6.6	5.7	5.4	.86	.82
Piatt(Sable)	7.2	7.4	3.9	0.9	.53	.12
				Average	.59	.38
				St. Dev.	.20	.24

PROJECT(soil series)	AVG. Eri (ksi)	50%ILE (ksi)	85%ILE (ksi)	100%ILE (ksi)	85%/50%	100%/50%
Williamson(Belknap)	8.0	7.7	6.7	5.0	.87	.65
Williamson(Bluford)	7.3	7.2	5.7	5.4	.79	.75
Williamson(Hick/Ava)	9.2	8.9	6.8	6.1	.76	.69
Williamson(Ava)	9.0	9.1	6.7	3.2	.74	.35
Average					.79	.61
St. Dev.					.06	.18

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